Office Of The Secretary Of Defense (OSD)
Deputy Director Of Defense Research & Engineering
Deputy Under Secretary Of Defense (Science & Technology)
Small Business Innovation Research (SBIR)

Program Description

Introduction

The Deputy Under Secretary of Defense (Science & Technology) SBIR Program is sponsoring two technology area initiatives this year, Cognitive Readiness Technology and Conditioned Based Maintenance Technology. We are also co-sponsoring two additional technology areas, biomedical technology and information technology for military health systems, with Defense Health Affairs.

All three services are participating in the OSD program this year. The service laboratories act as our OSD Agent in the management and execution of the contracts with small businesses. The Army, Navy and Air Force laboratories, often referred to as a DoD Component acting on behalf of the OSD, invite small business firms to submit proposals under this Small Business Innovation Research (SBIR) program solicitation.

Firms with strong research and development capabilities in science or engineering in any of the topic areas described in this section and with the ability to commercialize the results are encouraged to participate. Subject to availability of funds, DoD Components will support high quality research and development proposals of innovative concepts to solve the listed defense-related scientific or engineering problems, especially those concepts that also have high potential for commercialization in the private sector.

Objectives of the DoD SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research and development results.

The DoD Program presented in this solicitation strives to encourage technology transfer with a focus on advanced development projects with a high probability of commercialization success, both in the government and private sector. The guidelines presented in the solicitation incorporate and exploit the flexibility of the SBA Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to DoD and the private sector.

The topics are presented in four sections, corresponding to the technology areas cognitive readiness, conditioned-based maintenance, biomedical and information technology for military health systems. The topic descriptions, that follow this program overview section, are listed below.

The Cognitive Readiness Topics are:

- OSD01-CR01 Cognitive Fightability Index for Warrior Systems by the Army Research Laboratory
- OSD01-CR02 Field-Practical Automated Battery for Assessing and Monitoring Cognitive Readiness by the Army Research Laboratory
- OSD01-CR03 Screening Test for Detection of Major Psychiatric Disorders in Young Adults by the Army Medical Research Acquisition Activity
- OSD01-CR04 3D Components for Virtual Environments By the Army Simulation and Training Command (STRICOM)
- OSD01-CR05 Real Time Collective Performance Feedback For Combat by the Army Research Institute
- OSD01-CR06 Scenario Based Decision Skills Training for Geographically Distributed Teams by Air Force Research Lab Human Effectiveness Directorate, Williams AFB
- OSD01-CR07 Professional Leadership Development Skills Training for the 21st Century by Air Force Research Lab Human Effectiveness Directorate, Brooks AFB
- OSD01-CR08 Tactics, Training, and Procedures for the Warfighter Reacting to Crowd Dynamics by Air Force Research Lab Human Effectiveness Directorate, Brooks AFB
- OSD01-CR09 Cognitive Demands of Warfighter Readiness by Air Force Research Lab Human Effectiveness Directorate, Williams AFB

- OSD01-CR10 Assessment Methods for Tactical Knowledge and Cognitive Readiness of Intelligence Tasking, Processing, Exploitation and Dissemination (TPED) Teams by Williams AFB
- OSD01-CR11 Authoring Shell for Case-Based Instruction by the Office of Naval Research
- OSD01-CR12 The Grain Size Of Student Models As A Factor In ICAI Effectiveness by the Office of Naval Research
- OSD01-CR13 Toolbox/Intelligent Advisor for Creating Pedagogically Correct, Interesting and Motivating Instructional Content by the Naval Air Warfare Center
- OSD01-CR14 Intelligent Assistant for Web-based Training Vignette Design by the Naval Air Warfare Center
- OSD01-CR15 Instructional System for Enhancing Seakeeping Cognitive Readiness and Decision-Making Skills by the Special Operations Command

The Conditioned Based Maintenance Topics are:

- OSD01-CBM01 Airframe Health Monitoring using Acoustic Emission Crack Detection with Bragg Grating by Naval Air Systems Command
- OSD01-CBM02 "Smart" Machinery Spaces by Naval Sea Systems Command
- OSD01-CBM03 Fully Automated Bearing Residual Life Prognosis Wireless Sensor by Naval Sea Systems Command
- OSD01-CBM04 Fiber Optic Strain Field Measurement for Aging Aircraft by the Air Force Research Laboratory, WPAFB
- OSD01-CBM05 Development of an Evanescent Microwave Probe Scanner for Detecting and Assessing Corrosion Beneath Painted and/or Sealed Surfaces by the Air Force Research Laboratory, WPAFB
- OSD01-CBM06 In-Line Health Monitoring System for Aircraft Hydraulic Pumps & Motors by the Air Force Research Laboratory, WPAFB
- OSD01-CBM07 In-line Hydraulic Fluid Contamination Multi-Sensor by the Air Force Research Laboratory, WPAFB
- OSD01-CBM08 Fretting Fatigue Model by the Air Force Research Laboratory, WPAFB
- OSD01-CBM09 Reliability Algorithms for Corrosion Fatigue Assessments by the Air Force Research Laboratory, WPAFB
- OSD01-CBM10 Structural Component Substantiation Methodology by the Army Aviation and Missile Command
- OSD01-CBM11 Power Scavenging in a Cold, Dark Storage Environment by the Army Aviation and Missile Command
- OSD01-CBM12 Battery Optimized for Long Term Storage and Intermittent Use the Army Aviation and Missile Command
- OSD01-CBM13 Non-Destructive Life Prediction and Component Interaction Fault Tree for Energy Related Systems by the Engineering Research and Development Center, Construction Engineering Research Laboratory
- OSD01-CBM14 Smart Coating / Sensor Blankets for Health Monitoring by the Engineering Research and Development Center, Construction Engineering Research Laboratory

The Biomedical Topics are:

- OSD01-DHP01 Development of a Vaccine for the Treatment and/or Prevention of Cancer
- OSD01-DHP02 Development Of A Serum Based Biomarker For The Detection Of Cancer
- OSD01-DHP03 Lightweight Trauma Module
- OSD01-DHP04 Photoactivated Chemical for Tissue Bonding
- OSD01-DHP05 New Biosensors for Real-Time Terrestrial Toxicity Monitoring
- OSD01-DHP06 Rapid Diagnostics for Detection of Respiratory Pathogens
- OSD01-DHP07 Biomarkers of Musculoskeletal Soft-Tissue Injury
- OSD01-DHP08 Production Of Purified Recombinant Proteins For Development Of Vaccines Of Military Importance
- OSD01-DHP09 Reduction of Motion Side Effects and After Effects

The Information Technology for Military Health Systems Topics are:

- OSD01-DHP10 Technology Enhanced Human Interface to the Computerized Patient Record
- OSD01-DHP11 Cognitive Patient-Clinician Encounter Model
- OSD01-DHP12 Health Information Data Mining

SBIR Three Phase Program

Phase I is to determine, insofar as possible, the scientific or technical merit and feasibility of ideas submitted under the SBIR Program and will typically be one half-person year effort over a period not to exceed six months, with a dollar value up to $100,000. We plan to fund 3 Phase I contracts, on average, and downselect to one Phase II contract per topic. This is assuming that the proposals are sufficient in quality to fund these many. Proposals should concentrate on that research and development which will significantly contribute to proving the scientific and technical feasibility of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. The measure of Phase I success includes evaluations of the extent to which Phase II results would have the potential to yield a product or process of continuing importance to DoD and the private sector. Proposers are encouraged to consider whether the research and development they are proposing to DoD Components also has private sector potential, either for the proposed application or as a base for other.

Subsequent Phase II awards will be made to firms on the basis of results from the Phase I effort and the scientific and technical merit of the Phase II proposal. Phase II awards will typically cover 2 to 5 person-years of effort over a period generally not to exceed 24 months (subject to negotiation). Phase II is the principal research and development effort and is expected to produce a well defined deliverable prototype or process. A more comprehensive proposal will be required for Phase II.

Under Phase III, the DoD may award non-SBIR funded follow-on contracts for products or processes, which meet the component mission needs. This solicitation is designed, in part, to encourage the conversion of federally sponsored research and development innovation into private sector applications. The small business is expected to use non-federal capital to pursue private sector applications of the research and development.

This solicitation is for Phase I proposals only. Any proposal submitted under prior SBIR solicitations will not be considered under this solicitation; however, offerors who were not awarded a contract in response to a particular topic under prior SBIR solicitations are free to update or modify and submit the same or modified proposal if it is responsive to any of the topics listed in this section.

For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts, and have successfully completed their Phase I efforts, will be considered. DoD is not obligated to make any awards under Phase I, II, or III. DoD is not responsible for any money expended by the proposer before award of any contract. For specifics regarding the evaluation and award of Phase I or II contracts, please read the front section of this solicitation very carefully, as well as the Component’s specific requirements contained in their respective sections. Every Phase II proposal will be reviewed for overall merit based upon the criteria in section 4.3 of this solicitation, repeated below:

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.
b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.
c. The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.

In addition, each of the services and Defense Agencies have developed their own Phase II enhancement policy, which can also be found in there respective sections. The DDR&E topics will follows the Phase II enhancement policy corresponding to the topic author’s service. That is, the Army laboratories will follow the Army Phase II enhancement policy, the Navy topics will follow the Navy policy, and the Air Force laboratories topics will follow the Air Force policy. (Refer to their respective sections in this solicitation, or their website for details.)

The Fast Track provisions in section 4.0 of this solicitation apply as follows. Under the Fast Track policy, SBIR projects that attract matching cash from an outside investor for their Phase II effort have an opportunity to receive interim funding between Phases I and II, to be evaluated for Phase II under an expedited process, and to be selected for Phase II award provided they meet or exceed the technical thresholds and have met their Phase I technical goals, as discussed Section 4.5. Under the Fast Track Program, a company submits a Fast Track application, including statement of work and cost estimate, within 120 to 180 days of the award of a Phase I contract. Also submitted at this time is a commitment of third party funding for Phase II. Subsequently, the company must submit its Phase I Final Report and its Phase II proposal no later than 210 days after the effective date of Phase I, and must certify, within 45 days of being selected for Phase II award, that all matching funds have been transferred to the company. For projects that qualify for the Fast Track (as discussed in Section 4.5), DoD will evaluate the Phase II proposals under a separate, expedited process in accordance with the above criteria, and may select these proposals for Phase II award provided:

(1) they meet or exceed seletion criteria (a) and (b) above and
(2) the project has substantially met its Phase I technical goals.

(and assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Fast Track proposals, having attracted matching cash from an outside investor, presumptively meet criterion (c). However, selection and award of a Fast Track proposal is not mandated and DoD retains the discretion not to select or fund any Fast Track proposal.

Follow-On Funding

In addition to supporting scientific and engineering research and development, another important goal of the program is conversion of DoD-supported research and development into commercial products. Proposers are encouraged to obtain a contingent commitment for private follow-on funding prior to Phase II where it is felt that the research and development has commercial potential in the private sector. Proposers who feel that their research and development have the potential to meet private sector market needs, in addition to meeting DoD objectives, are encouraged to obtain non-federal follow-on funding for Phase III to pursue private sector development. The commitment should be obtained during the course of Phase I performance. This commitment may be contingent upon the DoD supported development meeting some specific technical objectives in Phase

II which if met, would justify non-federal funding to pursue further development for commercial purposes in Phase III. The recipient will be permitted to obtain commercial rights to any invention made in either Phase I or Phase II, subject to the patent policies stated elsewhere in this solicitation.

Contact with DoD

General informational questions pertaining to proposal instructions contained in this solicitation should be directed to the point of contact identified in the topic description section. Proposals should be mailed to the address identified for this purpose in the topic description section. Oral communications with DoD personnel regarding the technical content of this solicitation during the pre-solicitation phase are allowed, however, proposal evaluation is conducted only on the written submittal. Oral communications during the pre-solicitation period should be considered informal, and will not be factored into the selection for award of contracts. Oral communications subsequent to the pre-solicitation period, during the Phase I proposal preparation periods are prohibited for reasons of competitive fairness. Refer to the front section of the solicitation for the exact dates.

Proposal Submission

Proposals shall be submitted in response to a specific topic identified in the following topic description sections. Each topic has a point of contact to which the proposals shall be mailed. The topics listed are the only topics for which proposals will be accepted. Scientific and technical information assistance may be requested by using the DTIC SBIR Interactive Technical Information System (SITIS).

DUSD(S&T) Science And Technology Focus Area
Cognitive Readiness

The Deputy Under Secretary of Defense for Science and Technology DUSD(S&T) established a science and technology (S&T) focus area to explore Cognitive Readiness research issue. The Cognitive Readiness focus area provides a cross-component, multidisciplinary S&T framework to focus on the human dimension of joint warfighting capabilities. In addition, Cognitive Readiness serves to highlight a useful criterion for warfighting capability – fully prepared joint-warfighters, fighting and winning in an information rich, distributed firepower battlespace using human-centered hardware and systems.

The Cognitive Readiness focus area is intended to be highly responsive to achieving Joint Vision capabilities. *Joint Vision 2010* identifies readiness, in terms of people, training, leader development, and first-rate equipment, as the foundation for enabling joint operational capabilities. *Joint Vision 2020* reinforces and extends this philosophy by emphasizing and encouraging human innovation as the key force multiplier of the future. Hence, the goal of the Cognitive Readiness focus area is to enable a high degree of Warfighter readiness and mission performance with affordable systems and a smaller force deployed across the globe under diverse conditions. For the full range of weapon systems and Joint Operational Capabilities, Cognitive Readiness technologies are integral to major gains in operability, effectiveness, and affordability.

The optimization and enhancement of human performance is challenged by many different factors, such as general health issues, mental and physical stress, cultural and societal influences, environmental stressors (e.g., heat, cold, altitude, information overload), adequate education and training. Currently, there are two "core" Department of Defense program areas organized to address Cognitive Readiness issues, the Biomedical and Human Systems programs with subcomponents dealing in health, psychology, sociology, personnel and training, and human factors engineering issues.

The Cognitive Readiness topics selected for this solicitation are listed below and are on the following pages:

OSD01-CR01 Cognitive Fightability Index for Warrior Systems by the Army Research Laboratory

OSD01-CR02 Field-Practical Automated Battery for Assessing and Monitoring Cognitive Readiness by the Army Research Laboratory

OSD01-CR03 Screening Test for Detection of Major Psychiatric Disorders in Young Adults by the Army Medical Research Acquisition Activity

OSD01-CR04 3D Components for Virtual Environments By the Army Simulation and Training Command (STRICOM)

OSD01-CR05 Real Time Collective Performance Feedback For Combat by the Army Research Institute

OSD01-CR06 Scenario Based Decision Skills Training for Geographically Distributed Teams by Air Force Research Lab Human Effectiveness Directorate, Williams AFB

OSD01-CR07 Professional Leadership Development Skills Training for the 21st Century by Air Force Research Lab Human Effectiveness Directorate, Brooks AFB

OSD01CR-08 Tactics, Training, and Procedures for the Warfighter Reacting to Crowd Dynamics by Air Force Research Lab Human Effectiveness Directorate, Brooks AFB

OSD01-CR09 Cognitive Demands of Warfighter Readiness by Air Force Research Lab Human Effectiveness Directorate, Williams AFB

OSD01-CR10 Assessment Methods for Tactical Knowledge and Cognitive Readiness of Intelligence Tasking, Processing, Exploitation and Dissemination (TPED) Teams by Williams AFB

OSD01-CR11 Authoring Shell for Case-Based Instruction by the Office of Naval Research

OSD01-CR12 The Grain Size Of Student Models As A Factor In ICAI Effectiveness by the Office of Naval Research

OSD01-CR13 Toolbox/Intelligent Advisor for Creating Pedagogically Correct, Interesting and Motivating Instructional Content by the Naval Air Warfare Center

OSD01-CR14 Intelligent Assistant for Web-based Training Vignette Design by the Naval Air Warfare Center

OSD01-CR15 Instructional System for Enhancing Seakeeping Cognitive Readiness and Decision-Making Skills by the Special

Operations Command

TOPIC NUMBER: OSD01-CR01 **TITLE: Cognitive Fightability Index for Warrior Systems**

DoD CRITICAL TECHNOLOGY: Human Systems

MAIL ALL PROPOSALS TO:
U.S. Army Research Laboratory
ATTN: AMSRL-HR-SE (Linda Fatkin)
Building 459
Aberdeen Proving Ground, MD 21005-5425

OBJECTIVE: Develop an index of cognitive fightability through a systematic assessment of fightability attributes of human-centered hardware and systems.

DESCRIPTION: As technologies emerge and are investigated in support of the Joint Vision 2010 and 2020 objectives, developments across a wide range of disciplines tumble over each other in a technological and psychological avalanche. It is necessary to direct these efforts by addressing technological applications from the viewpoint of the soldier, and to assess the practical value added by digital systems to cognitive readiness and force effectiveness.

Cognitive fightability refers to the system's effects on soldiers' capabilities to perform mental functions contributing to optimal performance. Through systematic assessments of cognitive fightability, we can measure the system's enhancement or degradation of human cognitive performance. The Cognitive Fightability Index (CF Index) will be a critical tool when performing trade studies of system components resulting in direct input to system design and manpower requirements.

PHASE I: Identify and evaluate current cognitive taxonomies for their application to fightability classification. Prioritize and define the cognitive fightability attributes or factors in terms of human systems' effects on mental capabilities and task performance. A weighted combination of those factors would yield an overall score or CF Index.

PHASE II: Develop a standardized paradigm for evaluating cognitive fightability and for validating the prototype CF Index. Conduct research studies using the standardized CF paradigm in order to assess system attributes that might constrain or enhance human performance in a variety of contexts. Once validated, the CF Index can be used as a diagnostic tool for evaluating and for predicting human system integration levels within multiple scenarios.

PHASE III COMMERCIALIZATION POTENTIAL: The commercialization potential of this SBIR is extensive. There is a need for a standardized paradigm for evaluating cognitive fightability as a reliable method of quantifying cognitive readiness across a variety of disciplines. Within the private sector, the cognitive readiness index could be applied to the research and development of medical technology, distance learning and leadership techniques, training enhancements, and human systems integration technologies within a variety of other fields.

REFERENCES

1) Endsley, M.R., Holder, L.D., Leibrecht, B.C., Garland, D.J., Wampler, R.L., & Matthews, M.D. (2000). Modeling and Measuring Situational Awareness in the Infantry Operational Environment (Res. Rep. No. 1753). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences.
2) Fleishman, E.A., & Quaintance, M.K. (1984). Taxonomies of Human Performance: The Description of Human Tasks. New York: Academic Press.
3) Force XXI Land Warrior Future Warrior Architecture - Infantry Program (1999). Cognitive Fightability Evaluation Plan, presented to the FWA-I Independent Review Team, Scottsdale, AZ.
4) Perez, W.A., Masline, P.J., Ramsey, E.G., & Urban, K.E. (1987). Unified Tri-Services Cognitive Performance Assessment Battery: Review and Methodology (Tech.Rep.). Dayton, OH: Systems Research Labs. (ADA181697)
5) Peters, R. (1999). Our Old New Enemies. Parameters, Summer, 22-37.

KEYWORDS: cognitive fightability, human systems integration, system design decisions, fightability attributes, standardized paradigm, manpower requirements

TOPIC NUMBER: OSD01-CR02 TITLE: Field-Practical Automated Battery for Assessing and Monitoring Cognitive Readiness

DoD CRITICAL TECHNOLOGY: Human Systems

MAIL ALL PROPOSALS TO:
U.S. Army Research Laboratory
ATTN: AMSRL-HR-SE (Linda Fatkin)
Building 459
Aberdeen Proving Ground, MD 21005-5425

OBJECTIVE: Develop and validate a field-practical, cognitive readiness assessment battery validated for use within information-rich and high stress environments.

DESCRIPTION: In support of the Joint Warfighting Capability Objective regarding warrior readiness, numerous assessment tools have been developed throughout a wide range of disciplines. These efforts have been relatively isolated, resulting in fragmented methods for evaluating similar concepts. There is a dire need to evaluate the currently disjointed developments of cognitive assessment tools and identify common theoretical and practical frameworks. It is essential that key organizations and commands acknowledge, impart, and bring into play their interdependent capabilities for cognitive assessment. A gold standard for cognitive assessment batteries has been the Unified Tri-Services Cognitive Performance Assessment Battery. It is essential to build on those synergistic efforts established in the late 80's and incorporate recently developed assessment tools, such as noninvasive physiological measures, into current applications.

PHASE I: Develop a field-practical, automated tool capable of assessing cognitive readiness and stress resiliency within a variety of military scenarios. Cognitive readiness is defined as an enhanced state of mental acuity necessary for the warfighter to accomplish the mission while maintaining situational awareness of the operational environment. The "operational environment" typically includes varying intensities and durations of stressors. Consequently, in addition to measuring cognitive readiness, the assessment battery should include a standardized, yet noninvasive, physiological stress measure as an integral component of an overall stress metric. Efforts in Phase I must be coordinated with key cognitive researchers within the DoD, including the USAMRMC (WRAIR), the AFRL, the ONR, and other subject matter experts.

PHASE II: Develop a standardized paradigm to evaluate the multidimensional automated assessment tool within digitized scenarios and in urban environments as well. Conduct collaborative research investigations (a compendium of military agencies, academia, and industry) to validate the cognitive readiness battery and to mobilize mutually supporting efforts across various disciplines. This phase should culminate in the demonstration of the prototype battery.

PHASE III COMMERCIALIZATION POTENTIAL: The commercialization potential of this SBIR is extensive. There has been a significant need for a comprehensive, automated cognitive readiness battery within the private sector, particularly in areas such as private and public education (from pre-K through the college years), medicine, distance learning and leadership, training performance, adaptation to extreme environments, social cognition, human systems integration, and health, morale and welfare. As the automated battery is demonstrated and marketed in these areas, the potential for application to an extended range of other applications is phenomenal.

REFERENCES

1) dePontbriand, R.J., Ortega, S.V., Jr., Fatkin, L.T., & Hickey, C.A., Jr. (2000). Individual Soldier Test and Evaluation: Methods for Measuring Physical and Cognitive Performance. APG, MD: Army Research Laboratory, Human Research and Engineering Directorate.
2) Driskell, J.E., & Salas, E. (Eds.) (1996). Stress and Human Performance. Mahwah, NJ: Lawrence Erlbaum Assoc.
3) Elsmore, T.F. (1994). SYNWORK1: A PC-based tool for assessment of performance in a simulated work environment. Behavior Research Methods, Instrmts, & Computers, 26, 421-426.
4) Endsley, M.R., Holder, L.D., Leibrecht, B.C., Garland, D.J., Wampler, R.L., & Matthews, M.D. (2000). Modeling and Measuring Situational Awareness in the Infantry Operational Environment (Res. Rep. No. 1753). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences.
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9) Reeves, D.L., Winter, K., LaCour, S., Raynsford, K., Kay, G., Elsmore, T., & Hegge, F.W. (1992). Automated Neuropsychological Assessment Metrics Documentation. Washington, DC: Walter Reed Army Institute of Research, Office of Military Performance Asmt Technology.
10) Skosnik, P.D., Chatterton, R.T., Jr., Swisher, T., & Park, S. (2000). Modulation of attentional inhibition by norepinephrine and cortisol after psychological stress. International Journal of Psychophysiology, 36, 59-68.
11) Wilkins, W.L. (1982). Psychophysiological correlates of stress and human performance. In E.A. Alluisi & E.A. Fleishman (Eds.), Human performance and productivity: Stress and performance effectiveness. Hillsdale, NJ: Lawrence Erlbaum Associates.

KEYWORDS: cognitive readiness, cognitive assessment tools, automated battery, field-practical tool, collaborative research

TOPIC NUMBER: OSD01-CR03 TITLE: Screening Test for Detection of Major Psychiatric Disorders in Young Adults

DOD TECHNICAL AREA: Biomedical

ARMY MEDICAL PROPOSALS SHOULD BE MAILED TO:
US Army Medical Research Acquisition Activity
MCMR-AAU (Herman Willis)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: Develop a rapid, inexpensive method to screen military recruits for major psychiatric disorders or other behavioral factors that strongly predict occupational dysfunction in the military. Results should be standardized and interpretable by physicians without specialty training in psychiatry. The screening test should be reliable, and valid without significant health risk to persons tested. The goals are to identify individuals who may have psychiatric disorders which should be addressed prior to entry on active duty, as well as the early detection of conditions that could be addressed with appropriate intervention, thereby reducing attrition among those on active duty.

DESCRIPTION: Psychiatric disorders are common in young adults aged 17 to 25 which is the age-range of most of those applying for military service. Currently, there is no reliable screening tool used to identify those individuals at risk of having a mental health problem prior to accessing into the Army. Various screening programs that have been tried in the military have given inconsistent results. Psychiatric disorders are the number one cause of existed prior to service (EPTS) medical discharges from the military. In 1998, approximately 30% of all EPTS discharges were due to psychiatric conditions. The majority of these conditions were concealed at the time of accession to the military. These losses cost the military more than an estimated $27.3 million in 1998 in recruiting and accession costs alone (figure excludes costs of medical care, subsequent disability discharges, and associated attrition).

A simple screening tool during the application process might help identify those who should not enter active duty, as well as identify those who would benefit from appropriate interventions (e.g. mental health counseling, life skills training, etc.) while on active duty. For example, one study has shown that those identified to be at higher risk of developing depression during basic training have been helped by cognitive group therapy to gain the necessary coping skills to complete basic training process (personal communication, Dr. Reg Williams 8/00). Psychiatric disorders in young adults compromises the DOD's ability to recruit, access, train, and retain the manpower force needed to fulfill its global missions. A simple inexpensive screening test to use on a large number of individuals to detect common psychiatric disorders in young adults is needed to prevent the significant monetary and manpower losses to the military from premature attrition

PHASE I: Develop the feasibility concept design for new screening methodology to identify individuals at risk for the most common psychiatric disorders. Possibilities include, but are not limited to screening questionnaires or psychoactive pharmaceutical detection (to identify those who recently discontinued psychiatric medications). The screening methodology should be inexpensive and simple to use, and suitable for administration to large groups of individuals.

PHASE II: Demonstration of a prototype screen with measures of sensitivity, specificity, positive predictive value, and ease of correct performance of the test. The goal would be to reduce psychiatric related attrition from initial entry training by 10% or greater.

PHASE III DUAL USE APPLICATIONS: Psychiatric disorders is a major cause of expenditure of resources in the health care industry for civilian populations as well as the military. A psychiatric disorder screening methodology that could be used in a primary care setting offers the potential to correctly diagnose these common conditions in a timely and cost efficient manner, and ensure these individuals are medically managed appropriately. This methodology offers the potential of assessing the severity of the disorder and monitoring the response to therapy.

KEY WORDS: Mental disorders, screening, academic skill defects.

REFERENCES:

(1) Accession Medical Standards Analysis and Research Activity, 1999 Annual Report, Walter Reed Army Institute of Research, Silver Spring, MD

(2) Centers for Disease Control and Prevention. National Hospital Discharge Survey: Annual Summary, 1996. National Center for Health Statistics, Series 13 (no. 140), 1999.

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TOPIC NUMBER: OSD01-CR04 **TITLE: 3D Components for Virtual Environments**

DoD Critical Technology: Human Systems, Personnel Performance and Training

MAIL ALL PROPOSALS TO:
Rodney Long
STRICOM – AMSTI-ES
12350 Research Parkway
Orlando, FL 32826

OBJECTIVE: Develop a framework and supporting authoring tools for the structured design of 3D content based on reusable components. The tools will support the development of Advanced Distributed Learning (ADL) environments and shall be conformant with the Sharable Content Object Reference Model (SCORM).

DESCRIPTION: In November 1997, the Advanced Distributed Learning (ADL) initiative was launched to ensure access to high-quality education and training materials that can be tailored to individual learner needs and made available whenever and wherever they are required. This initiative is designed to accelerate large-scale development of dynamic and cost-effective learning software and to stimulate a vigorous market for these products in order to meet the education and training needs of the military and the nation's workforce in the 21st century. Through the SCORM, the ADL initiative is developing a common technical framework for computer and Web-based learning that will foster the creation of reusable learning content as "instructional objects."

With technical advances in personal computers such as advanced graphics cards, faster processors, increased memory, and high-speed modems, the use of 3D graphics over the World Wide Web has become widespread. While gaining popularity in the entertainment and e-commerce areas, the use of 3D content can also be very effective in educational environments, providing information visualization and interactive training simulations. However, there is still a lack of design experience and dedicated tools that allow the seamless integration of interactive 3D components in today's multimedia applications. 3D applications are usually developed from scratch, using tools that are very complex and require computer programming skills and expert knowledge of computer graphics, resulting in unacceptable development costs. In addition, the graphics developer is not the subject matter expert for the application content. What is needed is a development environment with a level of abstraction that hides the complexities of computer graphics and programming languages.

Current research has applied the concept of reusable components and frameworks to 3D computer graphics to provide this abstraction. 3D components are visual objects that have geometry and behavior. The geometry defines the shape of the object, size, color, etc. In addition, the 3D component may also have an associated behavior that causes it to change state, produce animations, and react to user input. The behavior can also cause changes in the component's geometry. A component's geometry and behavior must be encapsulated. In other words, the component is treated as a black box that is only accessible through a well-defined interface. Using the component interface mechanisms, 3D components can be integrated together to form new and more complex visual objects in a virtual environment.

Once the component interface mechanisms and framework have been defined, supporting authoring tools are required. These tools provide a level of abstraction that allows a content expert to assemble the components into a dynamic virtual environment to support ADL. The tools must provide a repository of reusable components with a taxonomy that is intuitive in assembling the components. Providing a framework and supporting authoring tools for 3D components will reduce development costs by managing the complexity of 3D development, encouraging reuse, and allowing the content expert to participate in the development process.

PHASE I: Develop a framework for the structured design of reusable, 3D components. Define component interfaces and how the geometry and behavior of dynamic 3D components will be encapsulated to promote reuse. Describe the development/authoring tools that will allow the reusable components to be combined to create a virtual environment. Using the SCORM, define the concept of a reusable learning object for this environment and how the SCORM's Application Program Interface (API) and metadata tags would be implemented.

PHASE II: Develop a prototype of the authoring tool, implementing the framework. Using the authoring tool, develop a small training application demonstrating reuse and reduced development costs and the ability to import and export content objects using the SCORM.

PHASE III DUAL-USE COMMERCIALIZATION: Provide a commercialized toolset that supports development of 3D virtual environments for ADL. The toolset could also have a wide range of applications including entertainment and information visualization.

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KEYWORDS: Virtual Environments, 3D Graphics, Components, Sharable Content Object Reference Model, Advanced Distributed Learning, Reuse

TOPIC NUMBER: OSD01-CR05 **TITLE: Real Time Collective Performance Feedback For Combat**

DOD Critical Technology: Cognitive Readiness

OBJECTIVE: Demonstrate value of providing realtime collective performance feedback supporting combat mission execution.

MAIL PROPOSALS TO:
U.S. Army Research Institute
Simulator Systems Research Unit
ATTN: Dr. Goldberg
12350 Research Parkway
Orlando, FL 32826

DESCRIPTION: After action review (AAR) aids illustrate key aspects of collective performance and provide military organizations with an improved perspective regarding exercise events. The need for timely feedback after collective training exercises has resulted in the development of automated AAR systems capable of creating AAR aids during exercises, with minimal operator interaction, for immediate use when the exercise ends. The state of the art of automated AAR systems allows non-programmers to change the rule sets guiding automated AAR aid production to fit specific exercises as illustrated by the Automated Training Analysis and Feedback System project and the ongoing upgrade of the Close Combat Tactical Trainer AAR system. The state of the art is also moving towards feedback systems that are embedded in operational systems, as illustrated by the Navy's Advanced Embedded Training Advanced Technology Demonstration (AET-ATD). The state of the art in feedback systems is also moving towards automated support of process-oriented measures of team performance as illustrated by the Shipmate project. This research is the logical follow-on to the Navy's AET-ATD. It expands the AET concept from individuals and small teams to larger, combined arms units. It also investigates the efficacy of online feedback beyond training applications to operational combat missions. Digitization of the battlespace has created a situation where much of the data used to create AAR aids in the constructive, virtual or live instrumented range environment can now be made available in the actual combat environment. We have the potential to provide organizations with feedback in time to take corrective actions by employing AAR systems as operational tools. The transition of AAR systems to an operational tool also provides a means of helping units address the explosive growth of data within the digitized battlespace.

PHASE ONE: This phase will produce a feasibility concept design for an operational realtime collective performance feedback system that exploits the availability of digital data. The first objective of this phase is to identify unit performance measurement targets of opportunity for demonstrating the value of an operational collective performance feedback tool for digitized units. The concept for the demonstration must employ only those sources of data that would be available to a unit in a combat environment. The concept must also avoid data collection and analysis activities that require additional staffing. That is, it should be possible to implement the concept using personnel that would normally be available in a mission situation. The second objective is to propose a low cost hardware and software approach to demonstrating the value of the concept in an Army exercise environment.

PHASE TWO: This phase will culminate in the demonstration of a prototype. Prototype software and procedures should be developed and applied to demonstrate the value of using an AAR system to provide digitized units with realtime feedback

PHASE III DUAL-USE COMMERCIALIZATION: The capability for providing collective performance feedback during task execution is particularly well suited to cases where the task is performed over a relatively short period of time, outcomes are highly critical, a mix of organizations must work together in performing the task, and one or more electronic data streams can be applied. The cooperative actions of federal emergency management administration, law enforcement, medical, fire, and location officials in responding to a natural or manmade disaster is an example of such a task. It is also a target application area where AAR aids have been employed to support post training exercise feedback sessions.

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2) Digital Systems: OC Smart Books providing brief descriptions of individual digital systems are available at www.atsc.army.mil/warmod/Warrior-T/products.html
3) Sample descriptions of collective tasks for digitized units: (a)Download viewer to supporting reading of Mission Training Plan (MTP) files from ftp://ftp.atsc.army.mil/ATMD/DCX%20Live%20Digital%20Data%20Collection%20Study/ (b) Download MTP files at ftp://ftp.atsc.army.mil/ATMD/DCX%20Live%20 Digital%20Data%20Collection%20Study/MTPs/
4) Navy Embedded Training and Team Training Measurement Techniques: A list of publications in this area can be found at http: www.ntsc.navy.mil/Org/CODE4/496/Bibliography/NewTT_Bib_2_TeamTr.htm. Publications likely to be available to a wide audience include: (a) Zachary, Bilazarian, Burns, and Cannon-Bowers (1997). Advanced embedded training concepts for shipboard systems in the Proceedings of the 19th Annual Interservice/ Industry Training System and Education Conference, Orlando, FL (CD-ROM) (b)Smith-Jentsch, Johnston, Cannon-Bowers, and Salas (1997). Team dimensional training: A Methodology for enhanced shipboard training in the Proceedings of the 19th Annual Interservice/ Industry Training System and Education Conference, Orlando, FL (CD-ROM).
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TOPIC NUMBER: OSD01-CR06 **TITLE: Scenario Based Decision Skills Training for Geographically Distributed Teams**

DoD CRITICAL TECHNOLOGY: Human Systems

MAIL ALL PROPOSALS TO:
Ms. Sabrina Davis
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OBJECTIVE: To develop, implement, and evaluate a scenario-based, distributed training system to enhance team, decision-making skills.

DESCRIPTION: Recent research across the services has demonstrated that team participation in scenario-based training exercises greatly enhances problem solving and decision making skills. Work conducted by the Army Research Institute emphasizes a structured approach to scenario-based training (Campbell, Quinkert, and Burnside, 2000). Researchers from the Naval Air Warfare Center's Training Systems Division have developed the Team Dimensional Training approach to enhancing performance of shipboard teams by focusing on the processes a crew employs to accomplish its objectives (Smith-Jentsch et al, 1998). Distributed Mission Training research conducted by the Air Force Research Laboratory emphasizes skill enhancements resulting not only from mission practice but also from inter-team interaction before the mission: planning and briefing, and after the mission: review and after-action analyses, (Crane, Robbins, and Bennett, 2000). Marine Corps squad leaders are using table-top tactical scenarios to improve their decision-making skills before engaging in field exercises (Pliske, McCloskey, and Klein, 1998). Further, this research is demonstrating that the most notable improvements in performance are for cognitive skills such as maintaining situation awareness and for skills requiring interactions among teams of warfighters who are normally geographically distant from each other such as fighter pilots and air weapons controllers. In future deployments, combat and combat-support teams from different units will be tasked to arrive in theater and quickly begin composite force operations. Research is required to design and develop scenario-based, home station training systems for these warfighters with the goal of enhancing team and inter-team skills and reducing spin-up time in theater.

PHASE I: Prior to Phase 1, resources for training geographically dispersed groups of combat-support personnel such as medical services or environmental health will be researched by the government and references including websites containing this information will be provided to contractor. During Phase 1, an initial cognitive task analysis will be conducted to identify the knowledge, skills and experiences required for competent mission performance. Phase 1 will conclude with a feasibility design of a distance, decision training system.

PHASE II: The goal of Phase 2 will be to fully develop and demonstrate the distance, decision skills training system. The products of Phase 2 will include the prototype system, sample training scenarios, and an architecture for developing similar systems for other specialties.

PHASE III: Distance decision skills training systems will have applications for any endeavor that requires rapid setup and coordination of multiple teams performing a common mission. Examples include emergency response teams (fire, police, hazardous materials, medical) and reactions to natural disasters (medical, civil preparedness, government). Phase 3 will incorporate laboratory and field trials of a productized system for the selected application.

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KEYWORDS: Cognitive task analysis; decision making; problem solving; deployment

TOPIC NUMBER: OSD01-CR07 **TITLE: Professional Leadership Development Skills Training for the 21st Century**

DoD CRITICAL TECHNOLOGY: Human Systems; Information Technology

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OBJECTIVE: Design and development of a computer-based simulation training system prototype for professional military leadership skills development.

DESCRIPTION: Critical to the development of current and future military leaders, is the ability to provide more effective skills training which takes into account dynamic, uncertain environments endemic to the 21st century. Changing mission requirements, and the implosion of the information age are placing our current and emerging military leaders into positions for which they can be ill equipped. This is due to lack of experience, training, or guidance, and compounded by a need to consider a myriad of legal, moral, and ethical processes and procedures that has and will become inherent in 21st century. The need therefore exists to improve current leadership development skills training to enable our leaders to face the myriad of challenges necessary to move their 'forces' toward warfighter readiness and mission performance effectiveness. It is envisioned that leadership development may be optimized and enhanced by providing education and training in both cognitive and non-cognitive skills development. The proposed research is therefore directed toward exploring the feasibility of designing and developing a computer-based training system prototype consisting of cognitive (e.g., critical thinking, problem solving, etc) and non-cognitive (e.g., motivation, emotional control, etc.) modules designed to teach such skills identified as required, or deemed essential for effective leadership development. The training system as well as the modules must demonstrate sound theoretical constructs, instructional strategies and modeling approaches, integrate a simulated practice environment and provide feedback. Additional characteristics of the training system will include: (a) a computer-managed instruction (CMI) tool to track and document student progress; (b) plug and play capability; and (c) conform to DIICOE standards and guidelines for utilizing commercially available off-the-shelf software/hardware ensuring compatibility across platforms, domains, etc. The training system will be developed for implementation via an internet/intranet environment and/or packaged as a stand-alone system.

PHASE I: This phase will consist of an identification of what types of cognitive and non-cognitive skills should be taught within the training system as well as justification for why these skills should be included. A further product of Phase I will be a comparison and contrast of various methods for teaching the types of leadership skills of interest as well as the feasibility of these methods within a computer-based environment. Results will be documented in a technical report at the end of Phase I, to include a plan for Phase II work to include how the proposer would develop and implement a training module to teach at least one cognitive and one non-cognitive skill for leadership development.

PHASE II: Design, development, and demonstration of prototype, to include cognitive and non-cognitive skills modules, scenarios; design, develop, and execute a test and evaluation of the prototype, with objective to produce fully functional product to commercialize in Phase III.

PHASE III: Tri-service, industry, and other commercial application.

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KEYWORDS: Decision-making, emotional intelligence, cognitive skills, instructional strategies

TOPIC NUMBER: OSD01-CR08 TITLE: Tactics, Training, and Procedures for the Warfighter Reacting to Crowd Dynamics

DoD CRITICAL TECHNOLOGY: Human Systems

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OBJECTIVE: Conduct research to develop tactics, training, and procedures for users of lethal and Non Lethal Weapons (NLWs) that would enhance their ability to rapidly assess the situation and determine the optimal course of action. Rapid and accurate assessment of potential agitation indicators in a crowd allows for better real time decisions and optimizing the applied force required to meet mission objectives while minimizing the level of conflict escalation.

DESCRIPTION: Cognitive readiness is critical to ensuring that today's and tomorrow's warfighters have superior and supportable technology to support their mission and to give them revolutionary war-winning capabilities. Emerging war-fighting concepts, for example, have multi-disciplinary teams deployed in support of the joint/combined air operations center and in response to acts of terrorism. Operations, across the spectrum of missions, must support surge/sustained taskings, resolve situational ambiguities, and mitigate data overload in order to produce decision-quality information for the commander. Innovative training and procedures are required to conduct rapid assessment of the crowd and determine the use of lethal and NLWs. Training for the use of conventional weapons has focused on pre-conflict planning to recognize crowd behavior and to identify motivational factors and cultural issues. Training that aids the warfighter in making rapid and accurate reactive decisions based on feedback from the crowd's behavior has not been adequately addressed. Developing and enhancing these reactive decision-making processes in those making lethal and NLW employment decisions would lower the probability of conflict escalation.

PHASE I: Emphasis will be on the role of the warfighter in the global theater. The impact of the threat will be analyzed with respect to the decision-making process. Conduct research to identify factors that could influence crowd behavior or mood (e.g., size, motivation, age range, cultural diversity). Identify existing training courses that use these factors to assess possible military action. Identify data regarding historical crowd behaviors (Chicago, 1968, Seattle, 1999) and consequences of the applied security responses. Develop an understanding of how actions by military or police forces modify crowd behavior based on the identified crowd behavior indicators. Define which courses of action were most beneficial in reducing crowd escalation. The methodology and findings will be documented in a technical report.

PHASE II: Conduct research required to develop tactics, training, and procedures that include Prepared Responses (e.g., crowd size, motivation, age range cultural diversity), but focuses on Reactive Responses (i.e., using feedback from the crowd to determine the decisions leading to the lowest level of escalation). Attention must be given to the manner in which the information is conveyed to the commander in order to produce decision-quality information without data overload. Computers and other information tools that are used to assess the situation and convey the information must be, from the crew-system interface perspective at least, compatible with both the operational tasks to be performed and the physical environment in which they are being conducted. Addressing these topics would aid the warfighter in determining the relevance, pertinence, and applicability of lethal and NLWs. Training effectiveness assessments would be conducted.

PHASE III DUAL-USE COMMERCIALIZATION: The developed tactics, procedures, and training course might be taught on a contract basis to military, government, and commercial customers. As an example, the developed course might be incorporated into broader courses, such as the Interservice NLWs Instructor Course (INLWIC) in Fort Leonard Wood, Missouri. In addition, the developed course would be applicable to numerous security forces, especially those using both lethal and NLWs (e.g., SWAT). In addition, the tactics, training, and procedures developed for assessing crowd dynamics would be applicable to humanitarian and crisis response teams situated in potentially hostile environments.

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4) Joint Publication 3-13, "Joint Doctrine for Information Operations," 9 October 1998 http://www.dtic.mil/doctrine/jel/operations.htm
5) Air Force Doctrine Document 2-5, "Information Operations," 5 August 1998 http://www.dtic.mil/doctrine/jel/usaf.htm
6) Joint Non-Lethal Weapons Program homepage http://iis.marcorsyscom.usmc.mil/jnlwd/

KEYWORDS: Chaos Theory, Cognitive Engineering, Human Factors, Information Warfare, Non Lethal Weapons, Psychology

TOPIC NUMBER: OSD01-CR09 **TITLE: Cognitive Demands of Warfighter Readiness**

DoD CRITICAL TECHNOLOGY: Human Systems

MAIL ALL PROPOSALS TO:
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OBJECTIVE: Identify the cognitive skills that contribute most heavily to effective combat mission planning for aviators, develop training interventions designed to develop these cognitive skills, and evaluate the impacts on subsequent mission planning performance.

DESCRIPTION: Researchers across the services are documenting an opportunity to enhance mission performance by improving mission planning and briefing (Nullmeyer, R.T., Crane, P., Cicero, G., & Spiker, V.A., 2000; Stout, R.J., Cannon-Bowers, J.A., Salas, E., & Milanovich, D.M., 1999). The Department of Defense is investing considerable resources to develop and field computer-based mission planning tools to support pre-mission activities. Other efforts are providing enhanced systems in the cockpit to provide near real time tactical information for aviators. In both cases, training for operators focuses mostly on equipment operation with little attention being paid to identifying and developing underlying cognitive skills. The generally low experience levels in today's crew force allow less time for "on the job" training, further increasing the need for active instructional interventions to develop such skills. Distributed Mission Training (DMT) has the potential to support such interventions (Nullmeyer, et.al, 2000). Research is needed to identify the skills required in both mission preparation and replanning during mission execution for effective performance, develop training interventions to develop these skills, and assess the impacts of the resulting training treatments.

PHASE I: The research team will develop a set of targeted planning skills through a review of existing DMT and mission planning and replanning reports, interviews of DMT participants to identify mission areas that are particularly sensitive to mission planning and replanning skills, and conduct of cognitive task analyses. Phase I will conclude with development of a feasibility concept design for training interventions that are designed to take advantage of DMT capabilities to develop critical mission preparation and replanning skills.

PHASE II: The outcome of this phase is a prototype demonstration of training interventions used in conjunction with DMT to improve the planning and replanning skills of aviators. The Phase I feasibility design concept will serve as the foundation for developing training interventions that are designed to enhance mission preparation and replanning skills. The impacts of this training on the performance of warfighters will be evaluated, and results will be used to fine-tune the training treatments. The domain selected for assessing the effectiveness of these interventions will include scenarios that were not used as primary Phase I data sources.

PHASE III: A validated training package with demonstrated ability to enhance mission planning and replanning skills has applicability across the services. In addition to aviation, the importance of these skills is recognized in a wide variety of dynamic task settings such as medicine and nuclear power plant operations.

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KEYWORDS: Cognitive task analysis, mission planning, decision making, problem solving

TOPIC NUMBER: OSD01-CR10 **TITLE: Assessment Methods for Tactical Knowledge and Cognitive Readiness of Intelligence Tasking, Processing, Exploitation and Dissemination (TPED) Teams**

DoD CRITICAL TECHNOLOGY: Information Systems Technology, Human Systems

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OBJECTIVE: Develop automated methods to assess Tactical Knowledge and Cognitive Readiness of Intelligence Tasking, Processing, Exploitation and Dissemination (TPED) Teams.

DESCRIPTION: This effort will conduct research to develop distributed, collaborative methods and criteria to systematically assess the knowledge acquisition and cognitive performance and readiness of warfighting teams. Of primary focus will be teams associated with the intelligence tasking, processing, exploitation and dissemination (TPED) process needed to support the Combined Air Operations Center (CAOC) and the AF Distributed Common Ground Station (DCGS). The DCGS is the primary integration cell for ISR in the Air Force. Of primary focus will be the generation of scenario-based knowledge assessment items and criteria related to the cognitive components of mission essential competencies which are required by operators and commanders in the CAOC/DCGS site. It will further provide a means of identifying instructionally valid strategies for remediating and refreshing specific and shared knowledge and skills which could be used to inform the design of simulation-based training and rehearsal events. A capability to automatically conduct knowledge assessments to evaluate the impact of simulation-based training and rehearsal technologies and to design instructional content (e.g., missions and scenarios) to foster knowledge acquisition and retention at team levels of analysis does not exist today. Ultimately, a distributed, collaborative approach to assessing the acquisition of complex knowledge provides critical information about how the team develops knowledge about, and improve their cognitive readiness regarding, critical tasks. These assessments are foundational in terms of specifying the content and structure of initial training, refresher training content and intervals, and just-in-time interventions that promote enhanced cognitive readiness. Moreover, a technology such as this could be used to assess the relative contribution of team member's knowledge to performance in a given intelligence synthesis and dissemination situation and data on their actions and responses. The data can be used to identify innovative solutions, misconceptions about the appropriate solution, and incorrect information that could be addressed in follow-on training and rehearsal activities. Similarly, teams with specific knowledge related to a given mission can be identified, assembled, and assessed more readily if relevant, objective knowledge acquisition measures are developed and used.

PHASE I: Phase I activities will result in proof-of-concept software methods defining critical CAOC/DCGS knowledge requirements and mission essential competencies for aerospace superiority missions. Phase I will also demonstrate the feasibility of developing an automated knowledge acquisition and assessment system for teams within the DCGS. As a precursor to Phase II activities knowledge assessment outcomes will be matched to training strategies for training and remediation. Phase I will also provide specifications for an integrated knowledge assessment and acquisition system specifically focused on teams.

PHASE II: Phase II will develop and demonstrate a suite of tools, techniques, methods and a common architecture for assessing the knowledge acquisition of warfighting teams in aerospace combat environments such as those supported by the CAOC/DCGS. As an additional activity in Phase II, an elaborated knowledge decomposition and analysis capability will be developed and delivered.

PHASE III DUAL USE COMMERCILIZATION: This effort will provide an integrated suite of tools, technologies and a general architecture for assessing knowledge acquisition for training and rehearsal. The benefits from such a capability to government and private sector agencies include targeting training and rehearsal activities and content to remediate specific knowledge shortfalls and reducing operator time-to-proficiency and error-rates.

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KEYWORDS: Affordability, Criterion development, Knowledge acquisition, Knowledge assessment, Performance measurement, Readiness evaluation, Team effectiveness, Workgroup effectiveness

TOPIC NUMBER: OSD01-CR11 **TITLE: Authoring Shell for Case-Based Instruction**

DoD Critical Technology: Advanced Distributed Learning

MAIL ALL PROPOSALS TO:
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OBJECTIVE: Develop an authoring shell that supports the effective use of case-based instruction in a wide range of applications to the development of complex skills.

DESCRIPTION: Case-based instruction is a major alternative instructional approach widely used in management training and certainly applicable as well to high level military training dealing with tactical and strategic decision making. Yet, there is little research on the process of case-based instruction and the design features that will maximize its effectiveness. A distinct instructional technology for case-based instruction has yet to emerge. Recent research by Gentner and Forbus of Northwestern University provides basic research foundations for what could become a new form of instructional technology for case-based instruction, especially for just-in-time training for major military decisions. Gentner and Forbus have studied how people retrieve potential analogous cases from their memories and how they make analogies and judge the quality of those analogies. They have done computational modeling of these mental processes as well. These computational models could form the basis of a system that could, for example, draw upon a large database of case examples to find those that would be considered good analogous cases to work with in preparing to address a new military decision making problem. Unfortunately, unaided human memory tends to retrieve cases with superficial resemblances to the present problem, whereas what humans judge to be good analogies depends upon deeper structural similarities. One reason for the instructional use of case examples is the belief that their rich contextual information will assist students in recognizing situations in which problem solving techniques they are learning can be applied. Some additional recent research by Gentner and collaborators in the school of business has shown that small differences in the way such cases are used instructional can make a big difference in the success of such knowledge transfer. An authoring shell for case-based instruction would help ensure that such more effective instructional methods are implemented.

PHASE I: In Phase I, the proposed authoring shell should be designed in detail, including the conceptual design for applications that would be produced with this authoring shell. A military-relevant application for which a body of case materials exists should be identified, perhaps in collaboration with an institution such as the National War College. Thought should be given to ways of incorporating systematic instructional objectives into the system, along with an individually adaptive intelligent tutoring approach to ensuring attainment of those objectives. The design should provide for web-based instructional delivery.

PHASE II: The authoring tool and demonstration application should be developed and demonstrated. The demonstration application should receive a practical evaluation with members of the target population of students.

PHASE III DUAL-USE COMMERCIALIZATION: Given the extensive use of case-based instruction in management training, this system should have high commercial potential both as a product in its own right and as the foundation for one or more business operations specializing in the development of case-based instructional products.

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KEYWORDS: Training technology, case-based instruction, military decision making.

TOPIC NUMBER: OSD01-CR12 TITLE: The Grain Size Of Student Models As A Factor In ICAI Effectiveness

DoD Critical Technology: Advanced Distributed Learning

MAIL ALL PROPOSALS TO:
Dr. Susan Chipman
Address: ONR Code 342
800 N. Quincy Street
Arlington, VA 22217-5660

OBJECTIVE: Determine how the grain size of student models impacts the effectiveness of artificially intelligent tutoring systems and build a generic tutoring engine appropriate for the grain-size determined to be most cost-effective.

DESCRIPTION: Over the last decade much research has been conducted to demonstrate the effectiveness of artificially intelligent tutoring technology. Overall, this research has found significantly improved student performance with the use of intelligent tutors, typically about one standard deviation improvement in achievement. Although, we know that these tutors are effective, they are very complex systems incorporating many instructional features. We do not know which of the components within the tutors account for most of the student learning. Many of the instructional features of the most successful tutors have very significant costs associated with them, so that decision makers in DoD training have a need to know what the value of these features is in order to maximize the cost-effectiveness of training as artificially intelligent tutoring moves toward practical implementation. For example, we do not know how fine-grained the student model needs to be. . The most successful family of intelligent tutors is based on a very fine-grained model of expertise, and this research group is now moving towards even more fine-grained models. Other intelligent tutors have used a much coarser level of description in their student models. We need to know how much added value there is from the more costly fine-grained model. In order to make this effort feasible within the financial constraints of the SBIR program, bidders should own or obtain the rights to work with a tutor or cognitive model at the fine production system level of description. Tutors can then be developed that adapt instruction to one or more coarser grained student models, such as models defined at the level of instructional objectives. A comparative instructional evaluation should then be conducted to determine how much the effectiveness of the tutor is affected by the grain size of the student model.

PHASE I: The proposal for Phase I should identify the fine-grained cognitive model or cognitive model and existing tutor to be used in the research effort. In Phase I, the study design should be developed in detail, including development of the more coarse grained models of the skills to be taught. Information about the costs of cognitive task analysis and cognitive model development should be recovered and analyzed and costs of development of the less fine-grained models alone estimated, in order to provide the cost element of a cost-effectiveness estimate.

PHASE II: In Phase II, development of the competing tutors must be completed and a comparative learning experiment conducted. In addition, the generic tutoring engine should be developed, work that should be integrated with the development of the tutors themselves.

PHASE III DUAL-USE COMMERCIALIZATION: .Ownership of a tutoring engine which this research has shown to be at a cost-effective grain size should position the company well for further business developing intelligent tutoring systems for both DoD and commercial industrial customers.

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KEYWORDS: Training technology, artificially intelligent tutoring, cost-effectiveness of training

TOPIC NUMBER: OSD01-CR13 **TITLE: Toolbox/Intelligent Advisor for Creating Pedagogically Correct, Interesting and Motivating Instructional Content**

MAIL ALL PROPOSALS TO:
Naval Air Warfare Center Training Systems Division
Attention: Bob Seltzer, Code 4.9.T
12350 Research Parkway
Orlando, FL 32826-3275
phone:(407)380-4115

OBJECTIVE: The purpose of this SBIR is to explore concepts leading to the development of a tool for designing or reworking web-based training content so that is inherently interesting, engaging, and motivating. Desired capabilities include the compatibility with Department of Defense (DOD) distributed learning networks, compatible with elements of the Shareable Content Object Reference Model (SCORM) and related standards, design of learning objects based upon reasonable instructional models, user selectable options, open modular architecture, and a web-based interface.

DESCRIPTION: Distance learning (DL) has been identified as an instructional tool that can significantly contribute to the development of high levels of skills and knowledge necessary to deal with increasingly complex weapon systems and wider ranges of missions. Content elements need to be sufficiently small so that they can stored in content repositories for re-purposing and reuse. But, less attention had been directed to the quality of the instructional content. There are tens of thousands of existing content products that could be converted to the SCORM model and related standards, and well as many new courses to be developed in a web-based format. It is well known that web-based instruction may not be as interesting and motivating as other methods of instruction. Web-based instruction may be boring and lack-luster. The drop-out rate in web-based training is higher than in the traditional classroom. In part, this may be due to lack of social interaction in the web-based training environment. There are many useful tools that can be used to create pedagogically correct instructional content, but practical guidelines and tools are needed to help instructional designers to produce content that is also interesting, engaging and motivating. Ultimately, the product should be composed of a toolbox of strategies and an intelligent advisor to help the developer match strategies to the particular material. The toolbox should include several major categories of motivational tools: (1) social interaction (e.g., incorporating on-line collaboration with other students);
(2) dynamic graphics and sound effects; and (3) gaming strategies (e.g. incorporating imaginary situations, competition, challenge, simulated danger, high response rates). The intelligent advisor should include an interface that would query the developer regarding characteristics and uses of the training content. Together, the intelligent advisor and the toolbox will make suggestions and provide guidance for possible ways to enhance existing content (ultimately the training developer may choose which tools to use), guide the developer through the steps necessary to implement the strategies, and evaluate the training effectiveness of the implementation.

PHASE I: Explore alternative approaches and the feasibility of an on-line tool for the development of pedagogically correct yet interesting and motivating courseware. The contractor shall formulate detailed plans for 1) building a prototype assistant and 2) testing its usefulness and effectiveness. The plans for the prototype shall provide justification for the chosen content based upon an in-depth understanding of Navy, Marine Corps, Air Force, Army, or DoD DL requirements. It shall be capable of installation on an existing Department of Defense DL network (e.g., Navy ADL, Marine Net, Total Army Distance Learning Program, or the

DoD ADL Co-Laboratory). The plans for prototype development shall also include methods to ensure compliance with DoD SCORM for the resulting content.

PHASE II: Following the plans formulated during Phase I, the contractor shall provide a more detailed analysis of the specific context for development and implementation. The contractor shall then develop, test, and demonstrate the prototype motivational tool.

PHASE III: The contractor shall produce a technology demonstration based on the prototype system developed under Phase II. This technology demonstration will consist of reworking an existing web-based training course using the motivational tool, and the content will be evaluated at a DoD training facility.

COMMERCIAL POTENTIAL: There are many potential applications for a tool to improve the quality of content within and outside the military. Many commercial organizations are using DL to train their personnel in a wide variety of tasks. Once the tool has been shown to improve interest and motivation in military distance learning, we expect that commercial developers will be eager to use it as well.

KEY WORDS: distance learning; SCORM; motivation; instructional design

TOPIC NUMBER: OSD01-CR14 **TITLE: Intelligent Assistant for Web-based Training Vignette Design**

MAIL ALL PROPOSALS TO:
Naval Air Warfare Center Training Systems Division
Attention: Bob Seltzer, Code 4.9.T
12350 Research Parkway
Orlando,FL 32826-3275
(407)380-4115

OBJECTIVE: The purpose of this SBIR is to explore advanced concepts leading to the design and development of an intelligent tool to aid instructors in the creation of training vignettes for use in distance learning settings. The desired capabilities for this tool include, but are not limited to, a web-based interface that provides templates for the creation of training vignettes, guidance on the development of vignettes, and strategies for assessing and providing feedback after vignettes. The desired hardware capabilities for this tool include, but are not limited to, the compatibility with Department of Defense (DoD) distributed learning networks including behind and over the firewall models, with elements of the Shareable Content Object Reference Model (SCORM) and related standards, and learning objects based upon reasonable instructional model, and an open modular architecture.

DESCRIPTION: Implementing distance learning in the military is presenting many challenges. Two such challenges are designing courses that are engaging and can be completed during relatively short periods of time. Instructional designers are searching for alternative techniques to present information that actively engages users beyond electronic page turning courses. Providing trainees with training vignettes that pose realistic situations to which trainees must respond may be one such technique. Well-designed training vignettes can capitalize on effective training strategies such as concentrating on a well defined learning objective, offering a simulated yet realistic situation, focusing on behavioral responses and not just knowledge, measuring performance and providing feedback. Furthermore, trainees should be able to complete a single training vignette in less time than the typical one-hour lesson.

PHASE I: Explore alternative approaches, architectures, and feasibility concepts for the use of intelligent technology for the development of training vignettes. The contractor shall formulate detailed plans for 1) building a prototype training vignette tool and 2) testing its usefulness and cost-effectiveness. The plans for the prototype shall provide justification for the chosen content based upon an in-depth understanding of Navy, Marine Corps, Air Force, Army, or DoD DL requirements. It shall be capable of installation on an existing Department of Defense DL network (e.g., Navy ADL, Marine Net, Total Army Distance Learning Program, or the DoD ADL Co-Laboratory). The plans for prototype development shall also include methods to ensure compliance with DoD SCORM requirements.

PHASE II: Following the plans formulated during Phase I, the contractor shall provide a more detailed analysis of the specific context for development and implementation. The contractor shall then develop, test, and demonstrate the prototype training vignette development tool.

PHASE III: The contractor shall produce a technology demonstration based on the prototype system developed under Phase II. This technology demonstration will consist of creating and testing multiple training vignettes and formats will be evaluated at a DoD training facility.

COMMERCIAL POTENTIAL: There are many potential applications for developing training vignettes within and outside the military. Many commercial organizations are using DL to train their personnel in a wide variety of tasks. Once intelligent tools have been shown to improve the cost-effectiveness as well as enhance performance, they will quickly be incorporated into many DL applications.

KEY WORDS: distance learning; SCORM; training development, training vignette

TOPIC NUMBER: OSD01-CR15 **TITLE: Instructional System for Enhancing Seakeeping Cognitive Readiness and Decision-Making Skills**

KEY TECHNOLOGY AREA: TRAINING

MAIL ALL PROPOSALS TO:
United States Special Operations Command
Attn: SOAL-KB/SBIR Program

7701 Tampa Point Blvd.
MacDill Air Force Base, Florida 33621
Phone number for express packages is 813-828-6512

OBJECTIVE: Due to their high performance, planing hull boat operations such as those performed by Naval Special Warfare (NSW) forces are more dangerous than operations with lower performance or larger maritime craft. These dangers are exacerbated if the helmsman does not understand the principles of negotiating wave conditions ("seakeeping") to avoid damage to the craft or crew. Seakeeping challenges take on an added dimension in military maritime operations because slowing down may not be an option given tight mission schedules and/or advancing threats. Seakeeping knowledge, skills, and abilities (KSAs) are generally acquired through years of on-the-job hands-on training experience. Crewmembers get injured and equipment is often damaged throughout the lengthy learning curve. The objectives of this topic are to: (1) identify the perceptual and cognitive KSAs that underlie seakeeping expertise; (2) develop instructional strategies to impart the perceptual and cognitive skills necessary to make accurate seakeeping judgements and decisions; (3) develop and demonstrate a prototype instructional system.

DESCRIPTION: Seakeeping expertise consists of acquired KSAs that involve integrated, interactive, and dynamic processing of information retrieved from both external (i.e., perceptual) and internal (i.e., cognitive) representations, through the interplay between perception and cognition. Mastery of the seakeeping task requires the honing of specific perceptual and cognitive (i.e., decision making) skills. Perceptual components of the seakeeping task consist of discriminating cues (perceptual invariants) that experienced helmsmen attend to in order to determine their seakeeping actions (e.g., wave height, periodicity, and direction of travel). These perceptual invariants must be recognized and interpreted to support effective seakeeping performance. Examples of cognitive decisions would be selecting the proper approach angle and speed, for a specific wave height, length, and direction. These judgements are made based on constant analysis of the perceptual cues that support the seakeeping task.

A comprehensive and detailed cognitive task analysis of the seakeeping task has not been located to date, and does not likely exist. This may be due in part to the non-verbal nature of the seakeeping task domain. That is, experts may be unaware of the perceptual/cognitive tasks he/she is performing (referred to as "meta-cognition") or may have difficulty verbalizing the stimulus/response contingencies of the seakeeping perception/action cycle. Thus, innovative knowledge elicitation approaches are necessary to identify principles of effective seakeeping that can serve as guidelines for instruction. Research is then needed to map innovative training interventions to the perceptual, cognitive, and psychomotor components of the seakeeping task, and training effectiveness must be empirically established.

Although some seakeeping strategies will vary as a function of craft dimensions, the perceptual invariants that give rise to effective seakeeping performance remain, for the most part, constant across platforms (e.g., various engines will sound differently as craft are launched through the air, but the informational value of the auditory cue remains the same). The instructional system should impart those seakeeping KSAs that are relevant across all types of small craft (i.e., less than 100 ft), but should also impart declarative knowledge about seakeeping strategies related to various hull lengths, speed, and wave height and periodicity.

PHASE I: Use knowledge elicitation techniques to perform a cognitive task analysis of the seakeeping task. Identify the knowledge, skills, abilities (KSA'S) that contribute to effective seakeeping performance. This task includes identification of the discriminating cues (perceptual invariants) and cognitive decisions that support effective seakeeping performance. Cognitive components should be in the form of "if __ then __" rules of thumb or principles of effective seakeeping. Validate seakeeping KSAs within a sample of subject Matter Experts (SMEs). Recommend standardized training methods, strategies, and techniques to impart the perceptual and cognitive skills necessary to make optimal seakeeping judgements and decisions. Develop a plan for a prototype instructional system that will impart seakeeping KSAs.

PHASE II: Devise seakeeping measures of effectiveness/measures of performance to be incorporated into a prototype seakeeping instructional system. Develop and demonstrate a prototype seakeeping KSA instructional system that incorporates performance measures and instructional features for recommended standardized training methods, strategies, and techniques to impart the perceptual and cognitive skills to optimize seakeeping judgements and decisions. Conduct a training effectiveness evaluation to determine which instructional features result in superior seakeeping performance using the prototype system.

PHASE III: Revise prototype seakeeping instructional system in accordance with sponsor's technical guidance. Transition the instructional system to military and other maritime training agencies.

COMMERCIAL POTENTIAL: An instructional system for training seakeeping KSAs would be useful to all DoD, non-DoD (e.g., USCG, Customs, and Federal Law Enforcement), and private maritime training institutions that impart seamanship skills. The instructional system would also be of interest to civilian boaters, particularly if it could be implemented on a personal computer. Other applications include a high-speed boat handling video game for the entertainment industry.

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KEY WORDS: seakeeping, seamanship, coxswainship, boat handling, shiphandling, sea conditions, sea state, marine effects, training

DUSD(S&T) Science And Technology Focus Area
Condition-Based Maintenance – Predictive Diagnostics

Maintenance comprises a major portion of the total operational cost for Department of Defense (DoD) weapons systems. Unnecessary or inappropriate maintenance contributes to inflated ownership costs and generally reduced readiness for deployable assets, while unscheduled maintenance requirements can be very costly and disruptive. Proper application of Condition-Based Maintenance (CBM) practices, which apply a methodology for the performance of maintenance only where there is objective evidence of need, as part of an overall maintenance effort can reduce operating and support (O&S) costs and work-hour requirements. Furthermore, maintenance decisions can be focused on those maintenance actions most needed to ensure safety and mission readiness. In doing so, CBM provides a means to manage the risk of mission-degrading failures.

Condition-Based Maintenance and Predictive Diagnostics are logical and appropriate successors to the very successful Reliability Centered Maintenance approach to equipment reliability and affordable operation. Ideally in condition-based maintenance, the operational health of specific components or a complex system is determined through sensors or a sensing system. This information then is used to make maintenance or operational usage decisions. Accurate and reliable predictors of current equipment health and the remaining useful life of equipment in service may be used to determine operating risk for the next operations or maintenance cycle, the most efficient scheduling of maintenance actions or inspections, or usage modifications to delay failure or repair. Prudent application of CBM has the potential to reduce operations and maintenance costs while stabilizing or increasing materiel readiness.

Advances in miniature sensors, life-prediction methodologies and real-time computation, signal processing and multi-sensor data fusion, and intelligent reasoning and control are providing a technological foundation for condition-based maintenance. Significant progress has been made in the rapid assessment of machinery condition through monitoring debris in lubricating oils and the condition of oils themselves, severity of hidden corrosion and general corrosiveness of environments, and acoustic and vibrational measures. Nevertheless, major challenges face the practical implementation of CBM technologies and operational practicality. Among these are the development and integration of self-powered or power-harvesting wireless micro-sensors capable of operating in high thermal or high mechanical load environments; models and methodologies that can predict health and expected life based on physical, mechanical, or other measurements; reliable methods to measure and predict corrosion degradation in unstable environments; predictive tools for advanced materials, materials systems, and structures and design concepts for in-service monitoring; and design tools to assist in selecting the most appropriate monitoring approach for a specific mechanical or electrical system.

The Condition-Based Maintenance Topics selected for this solicitation follow this section and are:

- OSD01-CBM01 Airframe Health Monitoring using Acoustic Emission Crack Detection with Bragg Grating by Naval Air Systems Command
- OSD01-CBM02 “Smart” Machinery Spaces by Naval Sea Systems Command
- OSD01-CBM03 Fully Automated Bearing Residual Life Prognosis Wireless Sensor by Naval Sea Systems Command
- OSD01-CBM04 Fiber Optic Strain Field Measurement for Aging Aircraft by the Air Force Research Laboratory, WPAFB
- OSD01-CBM05 Development of an Evanescent Microwave Probe Scanner for Detecting and Assessing Corrosion Beneath Painted and/or Sealed Surfaces by the Air Force Research Laboratory, WPAFB
- OSD01-CBM06 In-Line Health Monitoring System for Aircraft Hydraulic Pumps & Motors by the Air Force Research Laboratory, WPAFB
- OSD01-CBM07 In-line Hydraulic Fluid Contamination Multi-Sensor by the Air Force Research Laboratory, WPAFB
- OSD01-CBM08 Fretting Fatigue Model by the Air Force Research Laboratory, WPAFB
- OSD01-CBM09 Reliability Algorithms for Corrosion Fatigue Assessments by the Air Force Research Laboratory, WPAFB
- OSD01-CBM10 Structural Component Substantiation Methodology by the Army Aviation and Missile Command
- OSD01-CBM11 Power Scavenging in a Cold, Dark Storage Environment by the Army Aviation and Missile Command
- OSD01-CBM12 Battery Optimized for Long Term Storage and Intermittent Use the Army Aviation and Missile Command
- OSD01-CBM13 Non-Destructive Life Prediction and Component Interaction Fault Tree for Energy Related Systems by the Engineering Research and Development Center, Construction Engineering Research Laboratory
- OSD01-CBM14 Smart Coating / Sensor Blankets for Health Monitoring by the Engineering Research and Development Center, Construction Engineering Research Laboratory

TOPIC NUMBER: OSD01-CBM 01 **TITLE: Airframe Health Monitoring using Acoustic Emission Crack Detection with Bragg Grating**

Technology Area: Materials, NDE, Acoustic Emission

MAIL ALL PROPOSALS TO:
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Patuxent River, MD 20670

OBJECTIVE: Enable effective and objective maintenance and repair decisions by identifying incipient cracking in aircraft structure. The methodology could use a wide area embedded acoustic emission system based upon a fiber optic (Bragg Grating) sensor for airframe health monitoring.

DESCRIPTION: The system to be developed consists of an imbedded fiber optic (Bragg Grating) sensor system capable of recognizing the presence of fatigue induced microcracks during the early stages of initiation and growth. The system would not require electrical conductors or leads but would consist entirely of optical fibers and a central processor/demodulation system. The microcracks generate ultrasonic acoustic strain waves when the composite is strained. With the initiation of a crack, stress releases an acoustic wave with frequencies in the 30 kHz to 500 kHz range. A repeatable acoustic wave for calibration can be generated by carefully breaking a pencil-lead against a test block. When a pencil lead breaks, there is a sudden release of stress energy where the pencil is touching the test block. Similarly, this optical sensor system to be developed will respond to frequencies in the 30 kHz range and monitor locations of fatigue induced by cracks that can be analyzed by computer software through normal and/or simulated operations.

PHASE I: During the Phase I of the program the contractor will develop a system incorporating fiber bragg gratings to detect emission pulses (of the order of 30 kilohertz) given off by cracks. The pulses are created using a RF burst from a continuous wave. The system has to be able to detect the emitted pulses immediately. The contractor will determine the key parameters that need to be optimized in order to enhance detection sensitivity and to make it ready for field use.

PHASE II: During the Phase II of the program the contractor will develop and test a prototype system capable of detecting acoustic emissions in a platform. The system will be capable of interrogating large areas by detecting and recording small emission signals via embedded fiber bragg gratings. All the software programs and controls should be accessible to the operator in an easy and friendly manner. All the key parameters that were identified for optimization in phase I will be incorporated in the prototype.

PHASE III: A system of this nature could be used in any DoD platform (F-18, F-14, etc.), since they all have critical structural components that require health monitoring. Significant cost savings could be achieved by using a wide area inspection system of this nature since real time health monitoring would decrease inspection costs by reducing unnecessary inspections and tear-downs for inspection.

COMMERCIAL POTENTIAL: Commercial aviation would benefit significantly from a system of this nature as well. Wide spread fatigue damage has been determined to be a major source of problem for commercial and military aviation.

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KEY WORDS: NDE, wide area, fatigue, cracks, acoustic emission, bragg gratings

TOPIC NUMBER: OSD01-CBM02 **TITLE:** ***“Smart” Machinery Spaces***

DOD Critical Technology: Condition Based Maintenance

MAIL ALL PROPOSALS TO:
Ken Jacobs
Naval Sea Systems Command
2531 Jefferson Davis Highway
Arlington, VA 22242

OBJECTIVE: Develop methods and utilize technology to provide an onboard, remote wireless sensor network for single access point data retrieval and real-time monitoring of shipboard equipment to assist in Condition-Based Maintenance (CBM) and Remaining Useful Life (RUL) prediction.

DESCRIPTION: Current shipboard watch standing and plant equipment monitoring operations require the use of a “roving watch” to manually collect data from the various machinery spaces on a periodic basis. The Navy’s long term objectives are to reduce manning, move to paperless systems and improve the quality of life. To support these objectives, the development of “smart” machinery spaces to collect, monitor and process key equipment data would be in concert with the Navy’s end vision. These “smart” machinery spaces should use wireless technology, power harvesting methods, and a single access point data retrieval port. A wireless sensor network that extracts selected data will be a reliability-centered method to determine true equipment condition and provide an accurate indication of RUL. The envisioned method of data collection would be to utilize a wide array of wireless sensors mounted on or near the equipment that would extract desired data from existing sources. These capabilities would enable CBM and extend the useful life of equipment while reducing manpower.

PHASE I: Phase I would be a “proof of concept” and prototype system development consisting of the identification and application of a series of equipment sensors (monitoring temperature, pressure, current, voltage, etc.) tying into a network with a single point method of data retrieval. Predictive diagnostics and prognostic capabilities must be developed as part of the data processing software in order to determine the accurate status of the equipment health and provide a reliable RUL. The purpose of this Phase is to demonstrate the feasibility of using the wireless sensor technology network and processing software as an online real-time “snapshot” of the equipment health.

PHASE II: Build a demonstration system and successfully deploy it on representative system based either shipboard or at an appropriate shore based facility. This demonstration system should focus on a single subsystem and be simple to operate insuring a minimum of training or oversight. As part of the shipboard evaluation, the system accuracy should be compared against the current data collection methods. Further, develop the methods of power extraction (such as utilizing heat or vibration) to make the wireless sensor independent and self-sustaining. The Navy will provide access to a ship for prototype demonstration or suitable shore-based system at no cost to the SBIR contract.

PHASE III: Based upon the results of the evaluation and customer feedback, implement the system in a production environment. Obtain feedback from production personnel with regard to per unit costs and reliability. Make necessary revisions to the system and demonstrate its application to other shipboard systems or applications (such as combat system equipment). Investigate the application of the smart machinery space technology to include various commercial applications.

COMMERCIAL APPLICATIONS: With proper refinement and adaptation, this technology has commercial potential in various industries with equipment that must be monitored and subject to scheduled maintenance. Examples are oil refineries, natural gas facilities with remote pumping sites, power generation sites, oil platforms, barges and factories with co-generation facilities

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KEYWORDS: CBM**,** Online, Real-time, Reliability-Centered, Condition-Based, Remaining Useful Life Prediction, Predictive Diagnostics, Prognostics, Wireless technology

TOPIC NUMBER: OSD01-CBM03 **TITLE:** ***Fully Automated Bearing Residual Life Prognosis Wireless Sensor***

DoD Critical Technology: Sensors

MAIL ALL PROPOSALS TO:
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OBJECTIVE: Develop methods to fully automate bearing condition assessment without the need for human interpretation using wireless sensor technology. The purpose would be to provide a consistent and accurate status of bearing condition and the Remaining Useful Life (RUL) directly from the sensor.

DESCRIPTION: Pre-mature rolling element bearing failure can occur in up to 10 percent or more of rotating machinery failure modes. Bearing condition prognosis is needed to determine current bearing status and life expectancy. Advances in sensor technology have resulted in "smart" sensors that not only detect a certain parameter but can now process and manipulate the data for prognostic use. Smart sensors permanently mounted on each bearing and networked to a machinery analysis tool will advance condition-directed decisions and reduce bearing failures and resulting machinery damage significantly. Integrating wireless technology into the system will reduce the sensor's vulnerability and provide for a variety of information pick up methods whether by handheld device or a central machinery control system. The wireless smart sensors could be self-reporting and networked to communicate with neighboring sensors for full integration with monitoring systems. The end result would be to allow human decision-makers to instantly know the health of key bearings to facilitate appropriate action.

PHASE I: Develop and describe the technical merit of the proposed wireless sensor system that would detect bearing status and RUL. The results of this phase shall be a working prototype of the system which demonstrates the data collection and analysis function of the sensor system. Specifically, this system will be capable of developing the ***statistical confidence accuracy*** of trouble-free life prognosis for the monitored bearings. The system should be applicable to shipboard equipment operating in an at-sea environment.

PHASE II: Build a demonstration system and successfully deploy it on representative system based either shipboard or at an appropriate shore based facility conforming to the Phase I prognostic methods. This demonstration system should focus on a single subsystem and be simple to operate insuring a minimum of training or oversight. The Navy will provide access to a ship for prototype demonstration or suitable shore-based system at no cost to the SBIR contract. The results of this phase shall be the successful demonstration of the system to monitor bearing condition and provide a useful RUL prediction on the monitored equipment.

PHASE III DUAL-USE COMMERCIALIZATION: It is anticipated that condition prognosis sensors will be manufactured for shipboard applications and industrial factory markets that utilize rotating machinery. They must be able to communicate with reliable and robust wireless networks.

COMMERCIAL POTENTIAL: It is predicted that the wireless sensor system would be an invaluable asset to any commercial industry using rotating machinery.

REFERENCES:

1) A. Barkov, N. Barkova, J. Mitchell, "Condition Assessment and Life Prediction of Rolling Element Bearings", Sound & Vibration, 1995, June pp.10-17, September, pp.27-31. http://www.vibrotek.com/articles/sv95/part1/index.htm
2) Taylor, B, Leach, R, "Predicting a Bearing Failure", 2001, April, http://energypubs.com/issues/html/we9803_002.html
3) Wiley, J, "Two-Way Radio Creates Smart Microsensors", Sensor Technology, 2001, April, http://www.insights.com/sensor_tech.html
4) Li, Y., Zhang, C., Kurfess, T.R., Danyluk, S., and Liang, S.Y., 2000, "Diagnostics and Prognostics of a Single Surface Defect on Roller Bearings," IMechE J. of Mechanical Engineering Science, Part C, Vol. 214, No. C9, pp. 1173-1185.

KEYWORDS: condition; maintenance; prognosis; vibration; accelerometer; wireless; sensor

TOPIC NUMBER: OSD 01-CBM04 **TITLE: Fiber Optic Strain Field Measurement for Aging Aircraft**

DOD CRITICAL TECHNOLOGY: Materials/Processes

MAIL ALL PROPOSALS TO:
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OBJECTIVE: Develop distributed fiber optic Bragg Grating based strain field measurement system.

DESCRIPTION: The measurement of strain on aerospace structures is important for monitoring the effects of vehicle aging. Although traditional foil strain gauge systems can be used they are burdened by the costs associated with multiple sensor leads as well as their susceptibility to EMI and harsh environments. Distributed fiber optic sensors offer tremendous reductions in weight, size, and lead count making these measurements cost effective. Fiber optic sensors are also known to provide immunity to EMI and harsh environments. Traditional lab and flight testing as well as advanced applications such as vehicle health management and wing shape morphing will also benefit.

The Air Force is seeking a fiber optic measurement system that will allow for high spatial resolution strain sensing along the length of a single mode fiber. This system should allow over 1000 measurements per fiber while simultaneously reducing the size, weight, and complexity of the sensor interface. Systems based on closely spaced Bragg grating arrays and scattering inherent in the fiber itself have recently been demonstrated.[1,2] The system should also allow for the measurement of temperature and other engineering parameters due to the ability to tailor the response of the grating array. Bragg grating based systems are absolute measurements which enable monitoring of strain state over the life of the vehicle. If embedded in future composite structures these systems can also provide information on composite cure and residual strains from manufacturing.

PHASE I: A program in this area should address the requirements and goals described above, and provide a feasibility demonstration of the concepts proposed. Viability of the technology will be quantified in terms of the breadth of needs addressed and demonstration of a viable approach. The phase one product for a successful effort is the feasibility concept design of 1000 strain/local environmental measurements on a single fiber.

PHASE II: The product from Phase I would be further developed into a prototype system intended to be compatible with current USAF aircraft inspection and maintenance philosophy. The product of this phase of the effort will need to be lab demonstration of the prototype concept design.

PHASE III DUAL-USE COMMERCIALIZATION: A fiber optic strain field measurement system of this nature would be a valuable tool for both commercial and military aircraft to effectively monitor the effects of aging over the life of an aircraft.

REFERENCES:

1) Froggatt and Moore, "Distributed measurement of static strain in an optical fiber using multiple Bragg gratings at nominally equal wavelengths," Applied Optics, April 1, 1998.
2) Froggatt and Moore, "High spatial resolution distributed strain measurement in optical fiber using Rayleigh scatter," Applied Optics, April 1, 1998.

KEYWORDS: strain measurement, fiber optic, Braggs Grating

TOPIC NUMBER: OSD01-CBM05 TITLE: Development of an Evanescent Microwave Probe Scanner for Detecting and Assessing Corrosion Beneath Painted and/or Sealed Surfaces

DoD CRITICAL TECHNOLOGY: Materials and Processes

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OBJECTIVE: Design and manufacture an automated evanescent microwave probe scanner that field technicians can use as a non-destructive inspection tool for corrosion detection and assessment.

DESCRIPTION: It is a known fact that the USAF has a vast and extensive corrosion problem on its aging aircraft. Much of this corrosion is not visible to the naked eye or immediately detectable via current non-destructive inspection (NDI) techniques. For depot-level maintenance, these techniques include eddy current, ultrasound, dye penetrant, and X-ray. All of these NDI methods possess acceptable resolution and have their uses. However, there are also deleterious points to each. For example, X-ray must be accomplished during off-peak hours of maintenance to avoid exposing technicians to the harmful radiation, and interpreting the film may be considered an art form. For reliable results, eddy current and dye penetrant require comprehensive depainting and surface preparation of the structure to be evaluated, at the cost of time and money. Ultrasound can return ambiguous results to a novice NDI technician.

In contrast, evanescent microwave probes (EMP) have the ability to image subsurface features through poorly conducting materials, like paint, making EMP scanning a very viable option for detecting corrosion without depainting the area to be inspected. Evanescent microwave probes sense resonance frequency shift, power loss and DC level as a function of the conductivity, resistivity, and topology of a material. Because each of these factors in a metal can be changed locally by surface and near-surface defects, a change in measured parameters occurs when the probe passes over an area of corrosion. In research conducted by AFRL/MLMR on a 7075-T6 aluminum aircraft door, plots of the resonance frequency shift and power loss accurately demonstrated the existence of a corrosion pit measuring 100 microns (.1 mm) across. This pit had developed under several coats of paint and primer, making it not only invisible to the naked eye, but also undetectable with current NDI techniques. In fact, Zetec Corporation attempted to find this pit using their state-of-the-art laboratory eddy current systems, and failed. Steam cleaning followed by optical microscopy with dark field illumination finally brought the pit out. It is very likely that the corrosion would have grown unchallenged until serious structural damage had occurred. Therein lies the potential of evanescent microwave probe scanning for corrosion detection.

PHASE I: Given existing state-of-the-art evanescent microwave technology, conduct a feasibility demonstration to determine an optimum approach for employing evanescent microwave probes to detect and assess corrosion beneath painted and/or sealed surfaces. The concept scanning system must be portable. Candidate surfaces to be scanned include large curved areas, e.g. aircraft skins and panels.

PHASE II: 1) Develop a prototype evanescent microwave scanner that is ready for manufacturing optimization and testing; and 2) Demonstrate the effectiveness of the prototype through application to known AFRL-provided samples and USAF aircraft.

PHASE III: Commercial application is very broad, including DoD OEM's and their suppliers as well as the automotive industry. Application areas include the aforementioned corrosion detection, corrosion assessment, and the possible displacement of more subjective or costly non-destructive evaluation techniques.

REFERENCES:

1) Hatch (ed.), *Aluminum: Properties and Physical Metallurgy*, American Society for Metals, Metals Park, 1984
2) Tabib-Azar, Pathak, Ponchak &LeClair, "Nondestructive Superresolution Imaging of Defects and Nonuniformities in Metals, Semiconductors, Dielectrics, Composites, and Plants Using Evanescent Microwaves," *Review of Scientific Instruments*, Vol. 70, Number 6, 1999, p. 2783-3712
3) Robinson, "Third Harmonic Excitation Improves Resolution," *Photonics Spectra,* April 2001, p. 26.

KEYWORDS: evanescent microwaves; non-destructive evaluation/inspection; corrosion detection; aging aircraft; automated scanning

TOPIC NUMBER: OSD 01-CBM06 **TITLE: In-Line Health Monitoring System for Aircraft Hydraulic Pumps & Motors**

DOD CRITICAL TECHNOLOGY: Materials/Processes

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OBJECTIVE: Develop in-line monitoring system for early warning of impending failure of aircraft hydraulic pumps and motors

DESCRIPTION: The reliability of aircraft hydraulic pumps is critical for the safety of flight. To avoid catastrophic failures, the aircraft pumps/motors are replaced after a predetermined time interval. Sometimes, the pumps are replaced prematurely, and at other times catastrophic failures happen, thereby contaminating the entire hydraulic system. In some extreme cases, this catastrophic failure can result in loss of aircraft. In AFRL/MLBT pump tests, it has been observed that certain parameters develop unique characteristics when the pump is nearing failure. At this point the pump still has ~10% of its remaining useful life. If these parameters are captured electronically with an in-line health monitoring system, the pump/motor could be replaced before it failed catastrophically. Replacing the pumps/motors for cause would increase reliability, maintainability and readiness.

PHASE I: The concept's feasibility will be demonstrated using a bench-top health monitoring system consisting of pressure, flow, temperature and vibration sensors, and the necessary electronics. Synthetic electronic signals may be used to simulate the signal and signal-noise observed in the hydraulic pump tests as described in the references.

PHASE II: A miniature in-line pump health monitoring system, capable of recognizing the impending pump/motor failure, will be developed. The health of the pump/motor will be indicated by LEDs and/or stored in read-only memory that could be accessed by the maintenance staff. The system would be light weight, easy to use by the field level personnel, and fit in the high pressure lines of the aircraft hydraulic circuit. The system will be affordable and demonstrated in aircraft hydraulic pump tests.

PHASE III DUAL-USE COMMERCIALIZATION: The technology could be used in wide-ranging military and commercial applications. All military and civilian aircraft would benefit from an early warning of an impending hydraulic pump failure and the pumps would be replaced for cause, not after an arbitrary mean time between change. The same technology could be used in other industry wherever hydraulic pumps are used.

REFERENCES:

1) Sharma S.K., Snyder, C.E., Jr. and Gschwender, L.J., "Aircraft Hydraulic Pump Tests with Advanced Fire-Resistant Hydraulic Fluids," *Bench Testing of Industrial Fluid Lubrication and Wear Properties Used in Machinery Applications, ASTM STP 1404,* G. E. Totten, L.D. Wedeven, J.R. Dickey, M. Anderson, Eds, American Society for Testing and Materials, West Conshohocken, PA, 2001
2) Sharma S.K., Snyder, C.E., Jr. and Gschwender, L.J., Cecere, G.J., and Jenney, T.A., "Endurance Pump Tests with Fresh and Purified MIL-PRF-83282 Hydraulic Fluid," AFRL-ML-WP-TR-1999-4185, (1999)

KEYWORDS: hydraulic pumps, in-line health monitoring system, aircraft hydraulic fluid, aircraft hydraulic system, pump failure, sensors

TOPIC NUMBER: OSD 01-CBM07 **TITLE: In-line Hydraulic Fluid Contamination Multi-Sensor**

DOD CRITICAL TECHNOLOGY: Materials/Processes

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OBJECTIVE: Develop an in-line contamination sensor for particulate, water and chlorinated solvents

DESCRIPTION: Hydraulic fluid contamination in aerospace hydraulic systems is currently determined by taking hydraulic fluid samples in bottles and sending them to laboratories for analysis. This is time consuming and the fluid samples can become contaminated during the sampling process, making the analysis invalid. The time delay between the sample being taken is so long that in most cases the aircraft or ground support equipment from which the sample is taken has been re-deployed or used. If the aircraft has hydraulic fluid that is severely contaminated, hydraulic system problems could occur in flight that could, in the worst case scenario, result in an aircraft crash. If highly contaminated ground support equipment is used to service aircraft while the fluid analysis is being conducted, those aircraft hydraulic systems would also become contaminated. Both of these problems could be avoided by having an on-line contamination sensor available at the flight line. Another development that will require this technology is the new generation of ground support equipment, which is currently under development. This equipment will have a hydraulic fluid purification unit built in to assure that clean, contamination-free hydraulic fluid will be used to service Air Force aircraft. However, the technology described in this SBIR topic is required to tell the operator of the ground support equipment that the on-board purifier has adequately removed the contaminants from the hydraulic fluid to service the aircraft. In order for this technology to meet the requirements, it must be capable of determining the particulate contamination level, the water concentration and the chlorinated solvent concentration in hydraulic fluids in real time. In addition, the multi-sensor must be capable of having the desired control level of each contaminant individually set by the operator in such a manner that an indicator on the control panel will indicate when the fluid has been adequately purified, e.g., a red light turning to a green light for each individual contaminant. Simplicity of operation, calibration and maintenance shall be a high priority in the design of this multi-sensor. The sensor must have long term compatibility with MIL-PRF-83282 and MIL-PRF-87257, the two most widely used aerospace hydraulic fluids used by the Air Force. In order for this technology to reach its full potential, it must be affordable, lightweight and reliable

PHASE I: The anticipated results of the phase I effort are that the feasibility of the approach taken by the contractor has been proven to meet the objectives of the program. In addition, while a fully developed, actual device is not anticipated, a working prototype that demonstrates that the contractor’s final device will be capable of determining the particulate, water and chlorinated solvent contamination levels in aerospace hydraulic fluids, MIL-PRF-83282 and MIL-PRF-87257 in-situ and real-time.

PHASE II: The anticipated results of the phase II effort are the complete development of the multi-sensor in its final form and demonstration that it is capable of all of the requirements stated in the objective. The probable long-term compatibility of the sensor with the hydraulic fluids will be demonstrated by accelerated materials compatibility testing of the sensor materials of construction with MIL-PRF-83282 and MIL-PRF-87257 hydraulic fluids at temperatures up to 135°C. A full-scale, simple-to-operate working unit will be delivered to the Air Force for testing at the completion of the contract.

PHASE III DUAL-USE COMMERCIALIZATION: This technology is directly applicable to the new generation ground support equipment being developed with built-in fluid purifiers. The rapid, on-site capability to assure the hydraulic fluid quality is essential to avoid significant delays in servicing the aircraft. Another application for this technology will be direct determination of the hydraulic fluid quality in the aircraft when used as a stand-alone device. This technology will also have tremendous application opportunities in the private sector. It will have direct applicability to commercial aircraft hydraulic fluid quality assessment and with minor modifications, if any, will have applicability to industrial hydraulic fluid quality assessment.

REFERENCES:

1) Sharma S.K., Snyder, C.E., Jr. and Gschwender, L.J., Cecere, G.J., and Jenney, T.A., "Endurance Pump Tests with Fresh and Purified MIL-PRF-83282 Hydraulic Fluid," AFRL-ML-WP-TR-1999-4185, (1999)
2) Sharma, S.K., Snyder, C.E., Jr., Gschwender, L.J., Cecere, G.J., and Jenney, T., “Endurance Pump Tests with Fresh and Purified MIL-H-5606 Hydraulic Fluid,” AFRL-ML-WP-1998-4211, (1998).

KEYWORDS: hydraulic fluid quality, in-line multi-sensor, fluid particulate contamination, fluid water contamination, fluid chlorinated solvent contamination.

TOPIC NUMBER: OSD01-CBM08 **TITLE: Fretting Fatigue Model**

DoD Critical Technology: Materials/Processes

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OBJECTIVE: Develop model for fretting fatigue that can be integrated into a corrosion fatigue model.

DESCRIPTION: Condition-based maintenance (CBM) has the potential to improve safety and readiness, and reduce by 30% operation & support costs, which accounts for about 65% of total life-cycle costs. CBM requires a method or tool to assess the severity of damage that is detected and estimate how fast it will grow in order to plan for maintenance. There are primarily four root causes, individually and concomitantly, for the development and growth of damage in aircraft: fatigue, corrosion, fretting, and dynamic loads. Efforts are being made to abate the structural response to dynamic loads. An analytical model integrating the effects of corrosion, fatigue and fretting will be needed for an effective condition-based maintenance system. Work at AFRL to analytically model the interaction of fatigue and corrosion in developing structural damage using fracture mechanics has shown promise. Current models for fretting fatigue are not easily integrated into the framework of this corrosion fatigue model.

PHASE I: Develop framework for an analytical model of fretting fatigue that can be integrated with the corrosion fatigue framework. Outline how the fretting model can be implemented in an analysis tool and subsequently integrated into the corrosion fatigue framework. Determine critical data needed to develop a prototype model. Develop a validation and verification plan for the resulting prototype analysis tool.

PHASE II: Perform testing and analyses to obtain critical data for the prototype model development. Develop and document prototype analysis tool using the fretting fatigue model. Demonstrate the analysis tool. Determine the accuracy and reliability of the analysis tool as part of the validation and verification of the tool.

PHASE III DUAL-USE COMMERCIALIZATION: Fatigue analyses and corrosion control are performed in many industries as part of product design and maintenance: transportation (ground vehicle, train, aircraft, ship, space), power generation, chemical. The interaction of corrosion, fatigue and fretting has long been known in all these industries. However, the ability to analyze this interaction has been absent. A single analysis tool that would provide this capability would be attractive to all these industries. The potential for performing condition-based maintenance in the future should also be attractive.

REFERENCES:

(1) Lichtenwaler, Peter F.; White, Edward V.; and Baumann, Erwin W.; "Information processing for aerospace structural health monitoring," *Proceedings of SPIE – the International Society for Optical Engineering, Smart Structures and Materials 1998 – Industrial and Commercial Applications of Smart Structures Technologies*, Vol. 3326, pp. 406-417, 1998.

(2) McDowell, D.L.; Clayton, J.D.; and Bennett, V.P.; "Integrated diagnostic/prognostic tools for small cracks in structures," *Proceedings of the Institution of Mechanical Engineers, Part C – Journal of Mechanical Engineering Science*, Vol. 214, no. 9, pp. 1123-1140, 2000.

(3) Endo, K.; and Goto, H.; "Initiation and Propagation of Fretting Fatigue Cracks,"*Wear*, v. 38, pp. 311-324, 1976.

(4) Hattori, T.; Nakamura, M.; Sakata, H.; and Watanabe, T.; "Fretting Fatigue Analysis Using Fracture Mechanics," *JSME International Journal – Series 1*, Vol. 31, no. 1, pp. 100-107, 1988.

(5) Brooks, C.L.; Peeler, D.T.; Honeycutt, K.T.; and Prost-Domasky, S.; "Predictive Modeling for Corrosion Management: Modeling Fundamentals," *Proceedings of the Third Joint FAA/DoD/NASA Conference on Aging Aircraft (A00-1150101-01)*, Albuquerque, NM, 20-23 Sept. 1999. (Also available at: http://www.apesolutions.com/frm_link.htm).

KEYWORDS: Aircraft Maintenance, Structural Integrity, Fatigue (Mechanics), Corrosion, Life Expectancy (Service Life), Aging (Materials)

TOPIC NUMBER: OSD01-CBM09 **TITLE: Reliability Algorithms for Corrosion Fatigue Assessments**

DoD Critical Technology: Materials/Processes

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OBJECTIVE: Develop algorithms to estimate the reliability of corrosion fatigue damage assessments and remaining life estimates.

DESCRIPTION: Condition-based maintenance (CBM) has the potential to improve safety and readiness, and reduce by 30% operation & support costs, which accounts for about 65% of total life-cycle costs. Implementing CBM requires algorithms that can: (1) assess corrosion fatigue damage; (2) predict how the damage will grow; and (3) provide a reliability measure for (1) and (2). Work at AFRL to analytically model the interaction of fatigue and corrosion in developing damage using fracture mechanics has shown promise in assessing corrosion fatigue damage and estimating remaining life. However, no reliability measure (or estimate of the confidence in the results) is constructed in this model. The reliability measure includes the reliability of the damage detection and the reliability of the prediction for how that damage will grow. A reliability measure is essential for CBM using on-board diagnostics. It can also be used now by fleet managers who need to decide how soon maintenance or repairs need to be performed.

PHASE I: Identify the models and architecture of the algorithms that will be used to estimate the reliability of (1) corrosion and fatigue damage assessments and (2) damage growth and remaining life predictions. Determine critical data needed to implement the models in the algorithms. If data beyond what is in USAF databases, which is typically crack growth rates in corrosive environments, is needed to develop the models, a plan to obtain the needed data will need to be developed. This may include identifying other data sources. Identify how these algorithms can be integrated into the corrosion fatigue assessment framework. Develop a validation and verification plan for the prototype algorithms.

PHASE II: Obtain and analyze the data necessary to support the algorithm. Develop and demonstrate prototype algorithms. Validate and verify the prototype algorithms. Identify potential improvements and what data or work is needed to make the improvements.

PHASE III DUAL-USE COMMERCIALIZATION: Fatigue analyses are performed in many industries as part of product design and maintenance: transportation (ground vehicle, train, aircraft, ship, space), power generation, chemical. However, the numbers provided from this analysis are treated as deterministic with large safety factors (or uncertainty factors) used to account for scatter. A tool that would provide an estimate of the confidence in the results, and allow reducing the uncertainty factors, would be beneficial to all these industries. Integrating analysis of the effects of corrosion on structural life will make the tool more attractive. The potential for performing condition-based maintenance in the future should also be attractive.

REFERENCES:

(1) Lichtenwaler, Peter F.; White, Edward V.; and Baumann, Erwin W.; "Information processing for aerospace structural health monitoring," *Proceedings of SPIE – the International Society for Optical Engineering, Smart Structures and Materials 1998 – Industrial and Commercial Applications of Smart Structures Technologies*, Vol. 3326, pp. 406-417, 1998.
(2) McDowell, D.L.; Clayton, J.D.; and Bennett, V.P.; "Integrated diagnostic/prognostic tools for small cracks in structures," *Proceedings of the Institution of Mechanical Engineers, Part C – Journal of Mechanical Engineering Science*, Vol. 214, no. 9, pp. 1123-1140, 2000.
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(4) Skinn, D.A.; Gallagher, J.P.; Berens, A.P.; Huber, P.D.; and Smith, J.; "Damage Tolerant Design Handbook," WL-TR-94-4054, May 1994, vol. 1 to 5. (DTIC nos. ADA311686 through ADA31690)

KEYWORDS: Aircraft Maintenance, Structural Integrity, Fatigue (Mechanics), Corrosion, Life Expectancy (Service Life), Aging (Materials)

TOPIC NUMBER: OSD01-CBM10 **TITLE: Structural Component Substantiation Methodology**

DoD Critical Technology: Air Platforms

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OBJECTIVE: Develop a system methodology, utilizing data gathered by aircraft health and usage monitoring systems, to identify fatigue lives of structural aircraft components.

DESCRIPTION: The U.S. Army aviation fleet is comprised of various helicopter and fixed wing assets. Helicopters such as the AH-64 Apache and UH-60 Black Hawk comprise a large portion of the aviation inventory along with older OH-58 Kiowa and UH-1 Huey aircraft. Current practice is to utilize a "safe life" design approach with regards to these aircraft's critical dynamic components. The method, which uses a Miner's Linear Cumulative Damage* compilation of component fatigue strength, flight test loads, and customer's usage profile, does not quantify structural reliability either on a absolute basis or on a relative basis.(1). This process mandates that a structural and/or dynamic component be assigned a calculated retirement time, i.e. replacement, based on an expected operating flight spectrum. Aircraft components are replaced when aircraft flight hours reach a designated number regardless of the actual flight usage spectrum, which is never fully understood. This philosophy, while insuring an excellent flight safety record, has the potential to incur substantial operational and support costs, which may be unnecessary. Another drawback to this method is that the major helicopter manufacturers have their own variation of "safe-life" analyses and thus there is no general consensus on retirement times.(2) Several programs are currently on going directed towards identifying actual usage spectrums for U.S. Army helicopters. These Health and Usage Monitoring Systems (HUMS) employ a variety of sensors installed on the aircraft. These sensors include position and force sensors, accelerometers, G-meters, thermocouples, pressure transducers, etc. These sensors provide information on critical dynamic component issues such as rotor track and balance, and engine/turbine operation. Information recorded during aircraft flight can also be used to identify actual flight spectrums of these aircraft. What is needed is a methodology to utilize this "regime recognition" information to substantiate the structural reliability of the aircraft.

PHASE I: Develop a system methodology to utilize the HUMS data to identify maintenance actions for structural aircraft components. Data will be provided by the Government to quantify the selected methodology. The developed methodology should provide the same structural reliability as the existing safe life methodology.

PHASE II: Improve and enhance the methodology as required to identify fatigue lives of structural components. Demonstrate the methodology on sub-scale test articles. Develop a model of the component replacement/maintenance process to include field unit maintenance actions, logistics and supply actions, and parts procurement actions. Identify the changes necessary to the current model to fully utilize actual recorded usage data in a conditioned based maintenance system. Draw up guidelines for condition-based maintenance of articles selected.

PHASE III/COMMERCIAL POTENTIAL: Condition based maintenance plans and procedures are expected to have many commercial applications in the aviation (military and civilian), automotive, maritime, and various other industries. The main product or end item expected to result from this research will be a system methodology (in others words a computer based model or algorithm) which utilizes data/information already being obtained through health and usage monitoring systems. On-board systems (sensors and computer hardware/software) designed to monitor, diagnose, and evaluate structural component lives has the potential to improve safety, maintainability, and reliability and also reduce costs associated with airframes, ships, domestic power generators, etc. Any industry concerned with structural components that undergo repeated and/or cyclic loading can benefit from the technology that results from this SBIR program.

REFERENCES:

1) Thompson, A.E, Adams, D.O, "A computational Method for the Determination of Structural Reliability of Helicopter Dynamic Components", American Helicopter Society Annual forum, May 1990.
2) AGARD –R-674, "Helicopter Fatigue – A Review of Current Requirements and Substantiation Procedures", February 1979
3) Minor, M.A., "Cumulative Damage in Fatigue", J. Appl. Mech., vol. 12, Trans. ASME vol. 67, 1945 pp. A159-A164

TOPIC NUMBER: OSD01-CBM11 **TITLE: Power Scavenging in a Cold, Dark Storage Environment.**

MAIL PROPOSALS TO:

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OBJECTIVE: To provide research in power scavenging in a cold, dark, and static storage environment for use in health monitoring systems.

DESCRIPTION: The Army is in the process of fielding an environmental monitoring system to report environmental parameters from inside a missile container. A requirement for this health monitoring system is that it is invisible to the soldier. A serious challenge presents itself in the power requirements of such a system. The life of a missile can last 10 years and possibly even 20 years. To make this health monitoring system last as long as the munitions it is collecting data on, some sort of power scavenging technique will be required. One of the most difficult places to do this type of scavenging would be in bunker storage. The environment there has fairly cool temperatures, no light, and immobile.

PHASE I: Phase one of this research would be identifying existing techniques of power scavenging and relating them to their ideal environments that they supply power in, identifying environments that make power scavenging difficult, and make recommendations on how to scavenge power in these environments.

PHASE II: Phase II shall consist of prototyping power scavenging techniques in the cold, dark, static environments. Also the contractor will provide recommendations for bunker modifications to allow for sufficient power scavenging.

PHASE III DUAL USE COMMERCIALIZATION: Power scavenging techniques in cold dark storage areas could revolutionize the electronic market, in the same way solar power scavenging did. This technology could be used in conjunction with solar power cells and be able to provide charging ability during both night ant day.

REFERENCES:

1) Morita, Yasushi; Fujisawa, Toru; Tani, Tatsuo, "Moment performance of photovoltaic/thermal hybrid panel (Numerical analysis and exergetic evaluation)", Electrical Engineering in Japan (English translation of Denki Gakkai Ronbunshi) [Electr Eng Jpn], vol. 133, no. 2, pp. 43-51, Nov 2000

2) Wascheul, F; Cocquerelle, JL; Armelin, A, "Novel strategy to control battery recharging, complying with EN61000.3.2", IEEE INT SYMP IND ELECTRON, IEEE, PISCATAWAY, NJ, (USA), 1997, vol. 2, pp.507-510,

3) Wang, Xianming; Yasukawa, Eiki; Mori, Shoichiro, "Inhibition of anodic corrosion of aluminum cathode current collector on recharging in lithium imide electrolytes", Electrochimica Acta [Electrochim Acta], vol. 45, no. 17, pp.2688-2684, 2000

Key Words: power scavenging, rechargeable, environment,

TOPIC NUMBER: OSD01-CBM12 **TITLE: Battery Optimized for Long Term Storage and Intermittent Use**

MAIL PROPOSALS TO:
Commander
U.S. Army Aviation and Missile Command
AMSAM-AC-RD-AX, Attn: Mr. Richard Williams
Bldg. 5400, Rm. B132
Redstone Arsenal, Al 35898
Phone (256) 876-5207
Phone (256) 876-8062 (alternate)

OBJECTIVE: To provide research in small, durable (environmental extremes), long life, low voltage batteries for the use in health monitoring applications.

DESCRIPTION: The Army is in the process of fielding an environmental monitoring system to report environmental parameters from inside a missile container. A requirement for this health monitoring system is that it is invisible to the soldier. This requirement creates limitations to the health monitoring system (i.e. weight, size, dimensions, maintainability, etc.). The strict requirements of the health monitoring system eliminate several commercially available batteries from consideration, as they are currently configured. The health monitoring system is in need of a battery that is optimized for the following:

1) Long life (10+ years) with intermittent usage
2) Small form factor (dimensions must be small to fit into monitored entity)
3) Environmental extremes (ranges must be greater than the entity it is monitoring)
4) Voltage and current requirements (Will be dependent on hardware, slightly flexible, power management techniques will be used to prolong life)
5) Low cost

PHASE I: Phase I will consist of researching into battery types and configurations and identify the strengths and weaknesses of each scenario. From this data, trade off studies will be performed to determine what battery characteristics (i.e. battery chemistry, form, size, etc.) are preferred for the health monitoring system. Also recommendations will be made as to what battery or combination of different batteries will best suit the system needs, and what characteristics may provide a superior performance battery. (i.e. The battery chemistry from battery A in the geometric form of battery B.)

PHASE II: Phase II would consist of developing prototypes of the battery characteristics specified in Phase I and would also include validation testing of these prototypes.

PHASE III: DUAL USE COMMERCIALIZATION: A battery with the above desired characteristics (form, size, low voltage, extended life) could be a highly marketable item to electronic and MEMS manufacturing organizations. This battery technology would also be very useful on the data-collectors biologists use to track marine animals.

REFERENCES:

1) Park, YJ; Park, KS; Kim, JG; Kim, MK; Kim, HG; Chung, HT.; "Characterization of tin oxide/LiMn sub (2)0 sub (4) thin-film cell", Journal of Power Sources [J Power Sources], vol. 88, no. 0, pp.250-254, 2000

2) Banner, Julie A; Barnes, James A; Winchester, Clinton S.; "Continuing challenges in lithium battery development", IEEE Aerospace and Electronic Systems Magazine [IEEE Aerosp Electron Mag], vol. 15, no. 5, pp 31-33, 2000

3) Mantell, C. L., "Batteries and energy systems / C.L. Mantell": 2nd Edition, McGraw-Hill; New York, New York c1983

4) Pavlov, D; Ruevski, S; Naidenov, V; Sheytanov, G., "Influence of temperature, current, and number of cycles on the efficiency of the closed oxygen cycle in VRLA batteries", Journal of Power Sources [J Power Sources], vol. 85, no. 1, pp.164-171, 2000

5) Marinez, Carlos; Drori, Yossi; Cianco, Joe., "Components and techniques for managing smart batteries", Electronic Engineering (London) [Electron Eng London], vol. 72, no. 879, 5 ppp, 2000

Key Words: batteries, low voltage, extended battery life, form, size

TOPIC #: OSD01-CBM13 **TITLE: Non-Destructive Life Prediction and Component Interaction Fault Tree for Energy-Related Systems**

DoD CRITICAL TECHNOLOGY: Environmental Quality/Civil Engineering

MAIL ALL PROPOSALS TO:
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Express Mail: 2902 Newmark Drive
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OBJECTIVE: Develop a non-destructive testing (NDT) sensor network that can determine the condition of complex energy-related systems that operate in a corrosive and/or direct buried environment. The advanced sensor network would provide the data for predicting material properties and remaining life of energy system components such as distribution piping, boilers, chillers, and associated mechanical equipment. The diverse sensor network will include hardware to generate the necessary signals to detect mechanical properties such as strain and electrochemical properties such as corrosion scaling. Software will also be developed for processing the received signals to yield quantitative measurements of remaining life.

Key considerations are that the developed sensor array (1) must be usable in-situ, limited to soil surface access, (2) must not create any environmental problems or interfere with mechanical properties, (3) must produce quantitative results related to material properties and corrosivity, and (4) must interface with software (algorithms) that contain a comprehensive fault tree indicating component interactions and all possible failure pathways.

DESCRIPTION: Energy-related systems designed to provide heating and cooling contain various components such as boilers, chillers, cooling towers, associated mechanical equipment and distribution networks (direct, buried, or entrenched) that contain numbers of segments (pipes, etc.) and nodal intersection points. Currently, managers of energy systems maintain these systems by identifying components needing repair and fixing them as necessary. Manufacturers recommended maintenance schedules have not always been reliable guides for maintaining individual components, where accelerated degradation of a component is caused by incorrect operation and not by its own deficiencies. With the development of Engineered Management Systems (EMS), Army energy managers gained access to a set of repeatable inspection-based tools to help optimize system operation and prioritize maintenance requirements. What is needed is an NDT sensor array and software that can determine the remaining life of each component and the overall energy system. The components of an energy system are so closely interrelated that the failure of one component frequently degrades or overstresses the entire system. For example, if an expansion slip joint in a piping network seizes, damaging mechanical stresses may be transferred to segments or nodes hundreds of feet away. Various NDT technologies, such as acoustics, electromagnetics, and electrochemical (AC impedance) offer a good basis for a solution because their signals are affected directly by the material properties or the geometry of the material in which they are traveling, leading to quantitative measurements. Further, these techniques are environmentally friendly, are theoretically capable of traveling long distances in engineered systems, and can thoroughly interrogate a structure’s integrity. One of the basic problems that has to be solved during the development of the required NDT sensor array is that the wavelength or signal energy of the penetrating signal can become larger than the phenomenon being measured. Another basic problem to be resolved is the lack of understanding of the interactions of acoustics and electromagnetic waves with the corrosion product. These relationships must be understood to be able to infer certain material properties, such as strength and/or remaining life of the material.

The data from the sensor array would then interface with existing algorithms that assign a condition index (CI) to each component, combine the various CI's, and apply them to the appropriate fault tree to determine an overall CI for the energy system.

PHASE I: Select and justify the most appropriate NDT technology to permit in-situ single-sided measurements on energy systems. Select the most appropriate mathematical models to predict remaining life based upon details in signals modulated by corrosion products or loss of material properties. Investigate optimal wave shapes and signal energies to produce the greatest signal change when interacting with corrosion products. Develop prototype sensor array design and component interaction fault tree for a heating and cooling system.

PHASE II: Produce a prototype NDT sensor array for a heating and cooling system based upon the prototype design developed in Phase I. Interface the NDT sensor array with the component fault tree and test the functional measurement capability of the sensor array on model structures containing controlled defects. Refine the hardware, sensors, and component fault tree to obtain accurate life prediction. Demonstrate the operation of the refined field NDT sensor array and software on at least one heating and cooling system, with the specific objective of proving that useful engineering data can be obtained in the field under real operating conditions.

PHASE III: The military and commercial applications include district heating and cooling systems, decentralized heating and cooling systems.

REFERENCES:

(1) Marsh, C.P., B.A. Temple, and A. Kim, *Condition Prediction Model and Component Interaction Fault Tree for Heat Distribution Systems*, ERDC/CERL TR-01-35 (Engineer Research and Development Center/Construction Engineering Research Laboratory, April 2001)

(2) Marsh, C.P. and T.R. Laughton, *Boiling Manhole Heat-Loss Calculations*, USACERL TR 98/062, ADA350373 (ERDC/CERL, June 1998).

KEYWORDS: fault tree; heat distribution systems; corrosion; sensors; non-destructive testing; life prediction; piping

TOPIC NUMBER: OSD-CBM14 **TITLE: Smart Coatings / Sensor Blankets for Health Monitoring**

DoD CRITICAL TECHNOLOGY: Environmental Quality/Civil Engineering

MAIL ALL PROPOSALS TO:

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OBJECTIVE: To develop and test smart coatings that contain embedded sensors or other technology to monitor the health of a coated metal structure and detect and quantify coating degradation and substrate corrosion. An alternative approach is a blanket containing a sensor array that can be wrapped around a structure.

DESCRIPTION: Coating failure is a primary cause of corrosion of steel equipment and structures at Army installations and in the field. Inspection of coatings is primarily accomplished visually which is labor intensive and is not feasible in inaccessible areas of critical components without disassembly. In addition, the inspection is only qualitative and requires significant coating degradation and substrate corrosion to be detectable. Smart coatings with embedded sensors or sensor blankets would allow quantitative inspection of critical components on a periodic or continuous basis and would warn of coating degradation prior to significant deterioration of the structure. Development and laboratory testing of such smart coatings (or alternatively, sensor blankets) is needed to enable condition-based maintenance (CBM) and predictive analysis of critical structures. The resulting coatings will be validated and used on steel equipment at Army facilities.

PHASE I: Develop and test coatings with embedded sensors (or alternatively, sensor array blankets) that monitor corrosion of the actual coated structure, i.e., not corrosion of the sensor itself. Develop procedures to locate coating damage using an array of sensors. Demonstrate the feasibility to track coating degradation using paints, appliqués, or other coatings.

PHASE II: Perform development and laboratory testing of smart coatings (or alternatively, sensor blankets) which can be used on critical steel equipment used in corrosive environments. Develop associated health monitoring and predictive diagnostics procedures. Demonstrate and validate smart coatings (or alternatively, sensor blankets). The contractor may request the use of Army equipment or facilities to conduct the demonstration, at no cost to the SBIR contract.

PHASE III: This technology also represents a high payoff potential for the monitoring and maintenance of critical civilian structures, such as chemical reaction vessels, that are exposed to corrosive environments. Possible industries include chemical processing, pharmaceutical, microelectronics, pulp and paper, and aviation. Additional military applications include storage tanks, pipelines, aging aircraft, and Navy ships.

REFERENCES:

1. Davis, G.D., C.M. Dacres, and L.A. Krebs, "*In-Situ* Corrosion Sensor for Coating Testing and Screening," *Materials Performance* **39**(2), 46 (2000).
2. Davis, G.D., C.M. Dacres, and L.A. Krebs, "EIS-Based *In-Situ* Sensor for the Early Detection of Coating Degradation and Substrate Corrosion," *Corrosion2000,* Paper 275 (National Association of Corrosion Engineers, Houston, TX, 2000).

KEYWORDS: corrosion; coatings; degradation; sensors; condition-based maintenance; predictive diagnostics

OSD DEPUTY UNDER SECRETARY of DEFENSE (S&T) / DEFENSE HEALTH PROGRAM BIOMEDICAL TECHNOLOGY FOCUS AREA

The Jointly Sponsored Deputy Under Secretary of Defense (S&T) and Defense Health Program Office have established this focus area to explore biomedical technology research issues. The biomedical technology area is focused to yield essential technology in support of the DoD mission to provide health support and services to U.S. Armed Forces. Most national and international medical S&T investment is focused on public health problems of the general population. Military medical S&T is concerned with developing technologies in order to preserve combatants' health and optimal mission capabilities despite extraordinary battle and non-battle threats to their well being. Preservation of individual health and well being sustains warfighting capabilities. The Biomedical Reliance Panel is included within the overarching structure of the Armed Services Biomedical Research Evaluation and Management (ASBREM) Committee, which provides joint coordination and cooperation to ensure synergy across all biomedical programs.

We have chosen the following topics and Service Laboratory Executive Agents to manage the SBIR topics in this technology area:

- OSD01-DHP01 Development of a Vaccine for the Treatment and/or Prevention of Cancer by US Army Medical Research Acquisition Activity
- OSD01-DHP02 Development Of A Serum Based Biomarker For The Detection Of Cancer by US Army Medical Research Acquisition Activity
- OSD01-DHP03 Lightweight Trauma Module by US Army Medical Research Acquisition Activity
- OSD01-DHP04 Photoactivated Chemical for Tissue Bonding by US Army Medical Research Acquisition Activity
- OSD01-DHP05 New Biosensors for Real-Time Terrestrial Toxicity Monitoring by US Army Medical Research Acquisition Activity
- OSD01-DHP06 Rapid Diagnostics for Detection of Respiratory Pathogens by the Naval Health Research Center
- OSD01-DHP07 Biomarkers of Musculoskeletal Soft-Tissue Injury by the Naval Health Research Center
- OSD01-DHP08 Production Of Purified Recombinant Proteins For Development Of Vaccines Of Military Importance by the Naval Medical Research Center
- OSD01-DHP09 Reduction of Motion Side Effects and After Effects by the Special Operations Command

Descriptions of the biomedical topics are on the following pages.

U.S. ARMY MEDICAL RESEARCH ACQUISITION ACTIVITY TOPICS

TOPIC NUMBER OSD01-DHP01 **TITLE: Development Of A Vaccine For The Treatment And/Or Prevention Of Cancer**

DOD TECHNOLOGY AREA: Biomedical

ARMY MEDICAL PROPOSALS SHOULD BE MAILED TO:
US Army Medical Research Acquisition Activity
MCMR-AAU (Herman Willis)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: Design, develop and manufacture safe and effective vaccine(s) for the prevention and treatment of cancer.

DESCRIPTION: Currently available treatments have limited efficacy for a substantial proportion of patients with prostate, breast and ovarian cancer. In addition, there are few preventative procedures that have been demonstrated to be effective to reduce the occurrence of cancer for patients at high risk. In the United States, it is estimated that 31,900 men will die from prostate cancer, and 54,800 women will die from breast or ovarian cancer this year (1). The development of vaccine based therapy for the prevention and treatment of cancer would complement existing forms of therapy for these diseases. This approach could also benefit patients whose disease cannot be treated by conventional therapies, such as those that cannot be resected surgically, or have spread to multiple sites. A potential vaccine could employ a number of different approaches, including basis on tumor cells, carbohydrates, peptides and heat-shock proteins, DNA-based vaccination and the use of recombinant bacteria and viruses to deliver antigens or the DNA coding for antigens to target cells (2,3). The incorporation of dendritic cell technology in vaccine development also is an important advance (4). These leukocytes can be engineered to overexpress the antigen of interest, stimulating the immune system to induce protective and therapeutic immunity in animals (5). These novel vaccine technologies could be used to develop preventative and treatment modalities against a number of diseases, including HIV, malaria, hepatitis, H. Pylori, as well as cancer (6,7). The potential vaccine could have the ability to (a) safely induce the immune response in cancer patients against antigens associated with tumors and (b) have the potential to result in regression of an established tumor. A potent therapeutic vaccine could have the additional benefit of preventing the development of cancer in patients with high risk, or preventing recurrence in patients after initial treatment and remission.

PHASE I: The objective of Phase I is to develop the initial formulation of the vaccine that would be considered to have the potential for specific immunogenicity in patients with cancer. This would include data that demonstrates that the chosen antigen is specific for cancer cells, or elicits an immune response against cancer cells.

PHASE II: The objective of Phase II is to (a) develop sufficient resources needed for the production of a vaccine, (b) the clinical formulation of the vaccine and (c) conduct Phase I clinical trials in patients to determine the safety and immunogenicity of the vaccine.

PHASE III DUAL USE APPLICATIONS: . This phase would involve clinical trials of the vaccine for Food and Drug Administration marketability. This technology may permit the development of better vaccines for military personnel and their dependents as well as civilian populations who are at high risk for cancer or recurrence of cancer. In addition, this technology may permit development of better vaccines, and their delivery, for military personnel who are deployed to geographical regions with exotic endemic disease as well as both military personnel and civilian populations exposed to biological agents.

KEYWORDS: Vaccine delivery, Therapeutics, Cancer,

REFERENCES:

(1) American Cancer Society. 2000. Cancer Facts & Figures 2000.
(2) Chamberlain, R.S., 1999. Prospects for the therapeutic use of anticancer vaccines. Drugs, 57:309-325.
(3) Restifo, N.P., Ying, H., Hwang, L., Leitner, W.W. 2000. The promise of nucleic acid vaccines. Gene Ther. 7: 89-92.
(4) Matsue, H., Morita, A., Matsue, K., Takashima, A. 1999. New technologies toward dendritic cell-based cancer immunotherapies. J. Dermatol, 26:757-763.
(5) Timmerman, J.M. 1999. Dendritic cell vaccines for cancer immunotherapy. Annu. Rev. Med. 50: 507-529.
(6) Romano, G., Michell, P., Pacilio, C., Giordano, A. 2000. Latest developments in gene transfer technology: Achievements, perspectives and controversies over therapeutic applications. Stem Cells. 18: 19-39
(7) Liang, T.J., Rehermann, B., Seeff, L.B., Hoofnagle, J.H. 2000. Pathogenesis, natural history, treatment and prevention of hepatitis C. Ann Intern Med. 132: 296-305.

TOPIC NUMBER OSD01-DHP02 **TITLE: Development Of A Serum Based Biomarker For The Detection Of Cancer**

DOD TECHNOLOGY AREA: Biomedical

ARMY MEDICAL PROPOSALS SHOULD BE MAILED TO:
US Army Medical Research Acquisition Activity
MCMR-AAU (Herman Willis)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: Develop, design, and construct innovative screening modalities and associated materials to detect and/or diagnose pre-cancerous and cancerous lesions using serum based biomarker assays.

DESCRIPTION: The development of screening biomarkers to detect and/or diagnose pre-cancerous conditions, as well as cancerous lesions related to breast cancer, prostate cancer, and ovarian cancer, are needed to enhance diagnosis and treatment. The biomarkers currently utilized for ovarian and prostate cancer have sensitivities as low as 30% to 40% (1). It is recognized that PSA has limited value in androgen independent prostate cancer (2). Similarly, CA125 has been used as a serum marker for the detection and monitoring of ovarian cancer, but results have been disappointing (3). Better screening biomarkers are needed to enhance diagnostic capabilities. Patient care would be enhanced if cancer could be detected earlier in the course of the disease. Additionally, the course of therapy could be modified, potentially increasing effectiveness, if immediate assessment of efficacy using a serum based marker could be utilized. It is intended that the biomarkers extend the utility of the tests beyond those currently available, such as those currently used for prostate cancer (PSA) and ovarian cancer(CA125). The overall goal of this solicitation is to develop standardized tests that can act as reliable predictors and indicators of cancer development, effectiveness of treatment, and/or recurrence. The program is seeking the identification of biomarkers that are sensitive and specific for breast, prostate ovarian cancer, as well as other cancers.

PHASE I: The objective of Phase I is to identify and outline the feasibility and applicability of the putative biomarker(s). This will include data showing the detectability of the biomarker in tissue or cell-line samples with potential to be detected in easily collected body fluids, such as blood, saliva, or urine.

PHASE II: The objective of Phase II is to test the potential of the biomarker and the assay in cancer patients. This phase will include the development of an assay for the biomarker and testing with clinical samples to determine sensitivity and specificity. The goals for sensitivity and specificity are 95% or greater.

PHASE III DUAL USE APPLICATIONS: The development of very sensitive and highly specific biomarker assays that would accurately detect, diagnose, and monitor cancer, promises to be a tool for the clinician to detect cancer earlier, and customize care for individual patients. This phase would involve clinical trials of the screening modality for Food and Drug Administration marketability. Early diagnosis of breast, prostate and ovarian cancer, is needed to enhance the survival of military personnel and DOD beneficiaries from these diseases and to reduce health care costs.

KEYWORDS: Biomarker development, Cancer detection, Biotechnology

REFERENCES:

(1) DeVita, V.T., Hellman, S., Rosenberg, S.A., (eds). 1997. Cancer, Principles & Practice of Oncology. Lippincott-Raven, Pub.
(2) Kim, J., Logothetis, C.J. 1999. Serologic tumor markers, clinical biology and therapy of prostatic carcinoma. Urol Clin North Am, 26:281-290.
(3) Meyer, T., Rustin, G.J. 2000. Role of tumor markers in monitoring epithelial ovarian cancer. Br J Cancer. 82:1535-1538.

TOPIC NUMBER OSD01-DHP03 **TITLE: Lightweight Trauma Module**

DOD TECHNOLOGY AREA: Biomedical

ARMY MEDICAL PROPOSALS SHOULD BE MAILED TO:
US Army Medical Research Acquisition Activity

MCMR-AAU (Herman Willis)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: To develop a lightweight module that will attach to a standard military stretcher for the treatment of trauma patients.

DESCRIPTION: A major goal for this topic is a module weight of 50 pounds or less. It also should not exceed a depth of 1 foot, and a width no greater than the standard NATO stretcher (22 inches). The capability goals of the trauma module include vital signs monitoring, for blood pressure, pulse rate, cardiac rhythm, temperature, blood oxygen saturation, respiratory rate, expired tidal volume. In addition, the module shall have: a defibrillator capable of "hands off" operation; ventilator that does not require oxygen or compressed air to function; EKG machine; infusion capability; surgical suction device with both positive and intermittent capability; oxygen delivery device; and ability to support existing anesthesia device. The power requirements are standard 115 volts (50-60 hertz) and 11-30 volts DC with a minimum 30-minute electrical power back up system and provisions for external power.

PHASE I: Investigate engineering feasibility of the concept.

PHASE II: Design and fabricate a prototype for demonstration and evaluation by the military. Refine this design into a final pre-production prototype. Conduct appropriate testing and prepare for submittal to FDA for approval.

PHASE III: Develop production equipment and field a low rate of initial production followed by mass production for both the military and commercial markets.

DUAL USE: This device will also have applications in the commercial market where there are far more trauma cases from auto accidents, gun incidents etc.

KEYWORDS: trauma, life support, transport, emergency, medical care, combat trauma

REFERENCES:
(1) Military Medicine, Volume 160, January 1995
(2) Handbook on Ground Forces Attrition in Modern Warfare, Dupuny TN
(3) Battle Casualties, Springfield IL, Charles Thomas, 1952

TOPIC NUMBER OSD01-DHP04 **TITLE: Photoactivated Chemical for Tissue Bonding**

DOD TECHNOLOGY AREA: Biomedical

ARMY MEDICAL PROPOSALS SHOULD BE MAILED TO:
US Army Medical Research Acquisition Activity
MCMR-AAU (Herman Willis)
820 Chandler Street
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OBJECTIVE: To develop a novel photoactivated tissue adhesive for potential application in the repair of skin and blood vessels.

DESCRIPTION: Currently, wound closure requires suturing, which is time-consumptive for the combat surgeon. In order to decrease surgical time, laser welding has been extensively used to repair tissues such as skin, blood vessels and nerve. Laser welding, however, depends on attainment of high temperatures that denature collagen; such temperatures may also produce thermal damage to surrounding tissue. Recent results suggest that athermal tissue bonding to produce chemically-induced collagen crosslinking might be better suited to achieve repair, while also being less damaging to surrounding tissue. This topic seeks to develop a novel photoactivated tissue adhesive for repair of skin and blood vessels.

PHASE I: Identify a novel photoactivated crosslinking substance in vitro and determine whether this substance can produce bonds in tissues ex vivo. Requirements for such a tissue bonding substance include: 1) adhesion to collagen-containing tissues;

2) free radical production (which causes collagen crosslinking) on exposure to light energy insufficient to heat tissue; 3) collagen crosslinking occurring under conditions encountered within in vivo tissues (i.e., body temperature and under a "wet" environment); 4) no, or limited cytotoxicity; and, 5) the resulting bond should be at least as strong and provide tissue regrowth and healing at least comparable to the current standard of care (i.e., conventional suturing techniques). At the end of Phase I, in vitro and ex vivo data should be provided that demonstrates conceptual feasibility of the proposed substance in meeting the above requirements.

PHASE II: Demonstrate tissue bonding in a realistic environment, namely, in in vivo models of skin and blood vessel injury. The criteria for acceptance of tissue bonding as an appropriate adhesive strategy are: 1) the tensile strength of the repaired tissue is at least as good as that produced by conventional suturing techniques; 2) the total time of tissue repair accomplished using bonding techniques is at least that required for conventional suturing, if not shorter; and, 3) the inflammation and fibrosis produced at the repair site is less than or equal to that produced by conventional suturing techniques. The desired end product of Phase II is completion of an in vivo demonstration of a prototype substance that meets the above criteria.

PHASE III DUAL USE: A photoactivated tissue bonding substance could be used in a wide range of civilian medical applications to replace conventional suturing.

KEYWORDS: Tissue bonding, tissue repair, collagen crosslinking, laser, light energy

REFERENCES:
(1) Bass, LS and MR Treat. Laser tissue welding: A comprehensive review of current and future clinical applications. Lasers Surg. Med. 17:315-349, 1995
(2) Mulroy, L, J Kim, I Wu, P Scharper, SA Melki, DT Azar, RW Redmond, and IE Kochevar. Photochemical keratodesmos (PKD) for repair of lamellar corneal incisions. Invest Ophthalmol Vis Sci. 41:3335-40, 2000.

TOPIC NUMBER OSD01-DHP05 **TITLE: New Biosensors for Real-Time Terrestrial Toxicity Monitoring**

DOD TECHNOLOGY AREA: Biomedical

ARMY MEDICAL PROPOSALS SHOULD BE MAILED TO:
US Army Medical Research Acquisition Activity
MCMR-AAU (Herman Willis)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: The objective is to develop and integrate advanced biosensor technology in a field-deployable platform to provide continuous, real-time monitoring for developing toxic conditions in air. The platform will assess the possible impairment of our forces that may encounter toxic chemicals in the air during training or deployment.

DESCRIPTION: The U.S. Army Center for Environmental Health Research (USACEHR), in conducting research in the field of deployment toxicology, seeks new methods for real-time assessment of continuously-monitored biological endpoints to define the toxicity of environmental media.. Although many chemical or biochemical sensors are being developed to detect exposure to individual toxic materials, this effort focuses on using real-time biological responses to identify toxic hazards that may be due to unsuspected materials or the joint action of chemical mixtures and that can complement chemical sensor technology. Technologies are sought for incorporation into a sensor platform deployed in the environment to provide continuous, real-time monitoring information. Biosensors may range from cellular or sub-cellular systems to tissue-based biosensors or whole organisms. Important characteristics of the biosensor data for providing useful toxicity data are listed below. It is anticipated that more than one biosensor approach may be required to achieve these goals.
1. Sensitivity to a broad range of toxicants in air and rapid response (less than 10 minutes). Through appropriate biosensor selection and interpretation, provide real-time differential responses to various classes of toxic chemicals (toxic industrial chemicals/materials and military-unique substances).
2. Minimal interference caused by variations in environmental parameters such as temperature, humidity, etc.
3. Suitability for continuous, on-line data acquisition and analyses.
4. Capability for integration in a field-deployable platform.

PHASE I: Conduct research to demonstrate the efficacy of one or more individual biosensors for continuous, real-time toxicity detection. The biosensor(s) will be original or will represent significant extensions, applications, or improvements over published methods. Experimentation must show that the biosensor(s) exhibit the above characteristics. Proof of concept will be accomplished through at least one toxic exposure monitoring event identification using the biosensor(s).

PHASE II: Expand Phase I research to include additional biosensor(s) that will provide an array of biological indicators to accurately and continuously monitor developing toxic conditions in real time and to improve the system's ability to define the mode of action of applied toxicants. Integrate the biosensors into a field-deployable platform. Specific chemical sensors should be added, as required, to augment the biosensors. Real-time, continuous data from the platform will be provided in a format suitable for real-time off-platform transmission and remote analysis. The sensitivity and response characteristics of the proposed suite of biosensors will be evaluated through laboratory tests with various classes of chemicals including, but not limited to, pesticides, organic solvents, and military-unique substances.

PHASE III DUAL-USE APPLICATION: The field-deployable platform will be integrated with other similar platforms, creating a network to provide early warning of developing toxic conditions in air and their potential hazard to troops. A variety of field applications are possible, including assessment of environmental hazards to troops pre-, during, and post-deployment. Field tests will apply platform/network under variable environmental conditions. The new platforms will increase the reliability and usefulness of current biomonitoring technology by identifying potential toxic chemical hazards to troops. Also, the platforms may be used to monitor and assess the environmental impacts of military site activities and the compliance of such activities with regulatory requirements. Civilian applications include “air shed” monitoring in urban, agricultural, and industrial areas where exposures to toxic chemicals are an issue. USACEHR would consider providing non-SBIR funding after successful completion of Phase II.

REFERENCES:
(1) J.P. Obusek, “Warfighter Physiological Status Monitoring,” Army RD&A, July-August, 10-12 (1999).
(2) G.M. Murray, A.L. Jenkins, A. Bzhelyansky, and O.M. Uy, “Molecularly Imprinted Polymers for the Selective Sequestering and Sensing of Ions,” Johns Hopkins APL Technical Digest, 18(4), 464-471 (1997).
(3) J. White and J.S. Kauer, “Rapid Analyte Recognition in a Device Based on Optical Sensors and the Olfactory System,” Analytical Chemistry. 68(13), 2191-2202 (1996).

KEYWORDS: Biosensors, Real-time monitoring, Continuous monitoring, Terrestrial toxicity

NAVAL MEDICAL RESEARCH ACTIVITY TOPICS

TOPIC NUMBER OSD01-DHP06 **TITLE: Rapid Diagnostics for Detection of Respiratory Pathogens**

DOD TECHNOLOGY AREA: Biomedical; DUSD(S&T) Focus Area: Force Health Protection

MAIL ALL PROPOSALS TO:
Commanding Officer
Naval Health Research Center
Attn: LCDR Margaret Ryan, MC, USN
Code 25
PO Box 85122
San Diego, CA 92186-5122

OBJECTIVE: Develop simple point-of-care rapid diagnostic tools for the detection of emerging respiratory pathogens

DESCRIPTION: Epidemics of acute respiratory infection are common among military personnel. This has particularly been true of crowded training populations and large newly mobilized populations where sudden mixing and close contact of personnel from disparate regions of the United States, and numerous physical stressors, can quickly lead to morbidity affecting thousands of personnel. The etiology of the epidemics vary with season and geographical site but often include adenoviruses, influenza viruses, *Mycoplasma pneumoniae*, *Chlamydia pneumoniae*, *Streptococcus pneumoniae*, *Bordetella pertussis*, and *Streptococcus pyogenes*. As many of these pathogens cause adult infections, which have similar clinical presentations, clinicians and epidemiologists need rapid point-of-care diagnostic tools to discern epidemic etiology such that appropriate interventions may be made. Current testing such as that involving culture, serology and polymerase chain reaction, when available, often takes too long to be clinically relevant or is too technically complex for military field medical personnel to employ.

PHASE I: Development of feasibility and concept design. Using laboratory strains, simple, point-of-care, rapid diagnostic tools should be developed to identify emerging strains of militarily important respiratory pathogens such as: adenovirus type 4, adenovirus type 7, *Mycoplasma pneumonia*, *Chlamydia pneumoniae*, *Bordetella pertussis*, Respiratory syncytial virus, parainfluenza viruses 1, 2, and 3, and emerging strains of influenza A such as H5N1. Such rapid test technology should be simple such that a medical person with only a high school education may effectively use the tests. Similarly, the rapid test should be robust and not require complex medical equipment such that it may be taken into the military field environment without threat of compromising test accuracy.

PHASE II: Prototype testing. After laboratory design, prototypic tests should next be performed in human subjects in a clinical setting. Culture, serology, and / or other molecular methods should validate such testing.

PHASE III: Military field testing. Once successful in trial, prototype tests should be field-tested in military operational settings by military medical personnel and again validated against culture, serology, and/or other molecular methods. Results should be shared with civilian public health professionals since it is likely that such tests would have significant commercial value in the civilian setting in addition to their value in the military environment.

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KEYWORDS: respiratory infections; rapid detection; epidemiology; military medicine

TOPIC NUMBER OSD01-DHP07 **TITLE: Biomarkers of Musculoskeletal Soft- Tissue Injury**

DOD TECHNOLOGY AREA: Biomedical; DUSD(S&T) Focus Area: Force Health Protection

MAIL ALL PROPOSALS TO:
Commanding Officer
Naval Health Research Center
ATTN: LCDR Kujawa
P.O. Box 85122
San Diego, CA 92186-5122

OBJECTIVE: Identify, and develop field tests for, valid biomarkers of musculoskeletal soft-tissue injury.

DESCRIPTION: During the Persian Gulf War conflict, 35% of all injuries (3726 of 10,526) were musculoskeletal injuries. Of these, 1177 injuries were soft-tissue injuries. Soft-tissue injuries are not apparent on traditional x-rays. The standard diagnostic method for soft-tissue injuries is magnetic resonance imaging, which is relatively expensive and not available in the field. Inability to diagnose soft-tissue injuries in the theater of operations necessitated the evacuation of 65% (769 of 1177)[1].of casualties with soft-tissue injury. Evacuation of these casualties not only delayed diagnosis and treatment, it also resulted in a considerable additional cost in terms of logistics and replacement personnel. The capability of diagnosing these injuries in the theater of operations would result in earlier treatment of the injury and a decrease in the logistical costs of evacuation for injuries treatable on-site. The validation of specific biomarkers of musculoskeletal injury and the development of rapid, reliable field tests for those biomarkers[2], would result in earlier treatment of wounded personnel and savings resulting from decreased evacuation costs.

PHASE I: A number of biomarkers of muscle, collagen, and other soft-tissue injuries have been identified. Most of these markers are measured from serum and are relatively non-specific. In addition, biomarkers present in urine and/or saliva need to be screened. Urine and saliva have obvious advantages in ease and non-invasiveness of sample collection. Phase I will be a concept design to determine the feasibility of development of simple, reliable, and relatively inexpensive bioassays for markers of soft-tissue injury. These tests should be easy to perform by technicians under military field conditions.

PHASE II: Phase II will be a demonstration of prototype bioassays. Demonstration will include validity and reliability of the bioassays.

PHASE III DUAL-USE COMMERCIALIZATION: Soft-tissue injuries are a problem not just during armed conflicts, but during regular training of military personnel. Some occupations (e.g., Special Warfare personnel), are particularly likely to suffer a soft-tissue injury at some point during their career. An inexpensive, rapid test to diagnose these injuries would result in considerable savings, both in terms of money and time away from duty. In the commercial world, soft-tissue injuries are a major source of workmen's comp claims, yet may be difficult, expensive, and time-consuming to diagnose. An inexpensive test that could definitively prove that an injury exists would be of benefit to employers and employees alike.

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KEYWORDS: Biomarkers; soft-tissue injury; diagnostic test.

TOPIC NUMBER OSD01-DHP08 **TITLE: Production of Purified Recombinant Proteins for Development of Vaccines of Military Importance.**

DOD TECHNOLOGY AREA: Biomedical; DUSD(S&T) Focus Area: Force Health Protection

MAIL ALL PROPOSALS TO:
Commanding Officer, Naval Medical Research Center
Attn: CAPT D.J. Carucci, USN
503 Robert Grant Avenue (room 3A40)
Silver Spring, MD 20910-7500

OBJECTIVE: To express, produce and purify recombinant proteins for the development of vaccines of military importance.

DESCRIPTION: A major priority of the biomedical research conducted by the Department of Defense biomedical research is to develop effective vaccines for the prevention of emerging and re-emerging infectious diseases threats, and against biological warfare agents. We propose to use malaria as a model system to establish the capability for expressing and purifying properly folded recombinant proteins for vaccine development since, as compared to developing vaccines against viruses and bacteria, the development of effective malaria vaccines is complicated by the complexity of the parasite (multiple stage life cycle, large number of proteins expressed at each stage, variability of target antigens) and the complexity of the human host's response to the infection. Developing effective and sustainable vaccines against complex pathogens such as malaria may require the use of multiple immunogens and of multiple vaccine delivery systems depending upon which arms of the immune system are to be activated. Malaria vaccine development has focused on developing subunit vaccines that duplicate the protective immunity induced by immunization with radiation attenuated sporozoites (T cell mediated), or by lifelong exposure to natural infection (antibody mediated) (1,2). For both approaches, a major priority is the production of recombinant proteins that can be used to induce protective immune responses in vivo (either as recombinant protein prime/boost or DNA prime/recombinant protein boost vaccination strategies) (3, 4), or to evaluate vaccine-induced T cell and antibody immune responses in vitro. Accordingly, this topic requests development of efficient methods for expressing, purifying and producing recombinant *Plasmodium falciparum* proteins for use as in vitro antigens and in vivo immunogens. The production of such proteins is complicated by the enormous difficulties in expressing intact *Plasmodium* proteins as compared with expressing bacterial or viral proteins, by the requirement for pure protein preparations free of contaminants which would induce nonspecific responses, and by the requirement for large-scale GMP-grade production of such proteins for use as immunogens in vivo. Therefore, critical aspects which must be met by competing companies include: (I) documented experience with expressing, producing and purifying *Plasmodium falciparum* proteins, including proteins which have been documented to have biological activity in vitro and in vivo; (ii) documented experience with manufacture under Good Manufacturing Practices (GMP) of recombinant proteins that have been used in human clinical trials; and (iii) demonstrated experience producing therapeutic proteins under GMP conditions with yields greater than 100 mg/liter.

PHASE I: In order to demonstrate the feasibility of the concept and design, express *Plasmodium falciparum* recombinant proteins, fully characterize the expressed proteins, and demonstrate in vitro expression of the proteins, antigenicity in vitro, and immunogenicity in mice and/or non-human primates.

PHASE II: Produce and purify recombinant *Plasmodium falciparum* proteins under Good Laboratory Practices (GLP) conditions, fully characterize the proteins, and demonstrate antigenicity and immunogenicity and in some cases protective efficacy in non-human primates. Finalize prototype that can be transitioned to clinical testing in Phase III and eventual commercialization.

PHASE III: Develop and demonstrate plans for transitioning to Good Manufacturing Practices (GMP) production, conducting pre-clinical safety studies, and submitting investigational new drug applications (IND) to the FDA. Manufacture under Good Manufacturing Conditions (GMP) conditions, conduct pre-clinical safety and immunogenicity studies in support of investigational new drug (IND) applications to the Food and Drug Administration (FDA), prepare IND, submit IND, conduct Phase I/II safety, immunogenicity, and protective efficacy studies in human volunteers, and perform regulatory oversight of such studies.

DUAL USE-COMMERCIALIZATION: The recombinant proteins produced in response to this topic have the potential to be developed as a vaccine against malaria, either as a recombinant protein in adjuvant approach or as a component of a prime/boost vaccine strategy. A successful malaria vaccine will eliminate the need for chemoprophylaxis in deployed troops and will prevent the degradation of fighting capabilities due to malaria infection. In addition, such a vaccine would protect civilian travelers and residents of malaria endemic areas. It is anticipated that the vaccine technologies developed will be applicable to a variety of traditional and emerging infectious diseases.

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KEYWORDS: Proteins; Vaccines; Biotechnology; Immunology; Malaria; Infectious Diseases

TOPIC NUMBER OSD01-DHP09 **TITLE: Reduction of Motion Side Effects and After Effects**

MAIL ALL PROPOSALS TO:
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7701 Tampa Point Blvd.
MacDill Air Force Base, Florida 33621
Phone number for express packages is 813-828-6512

TECHNOLOGY AREAS: Human Systems, Cognitive Readiness

OBJECTIVE: Develop methods and devices for reducing side-effects due to motion.

DESCRIPTION: Special Operations Forces are often required to deploy troops by sea and air in platforms designed to optimize war-fighting characteristics such as speed, endurance, survivability and agility. Such craft can induce significant motion side effects in the deployment force. These debilitating side effects are exasperated by relatively poor visual cues due to restricted visibility quarters and, frequently, nighttime or inclement weather deployments. Side effects include nausea, vomiting, cognitive degradation (e.g., reduced reaction times, poor mental acuity and agility), postural disorientation and drowsiness that can last for several hours and that can negatively impact the physical and cognitive mission readiness of the forces upon their arrival in the operation area. To an appreciable degree, these side effects are induced by the discordance of the visual environment with the sensed, motion environment. Similar situations can arise in personnel operating in, hovercraft, amphibious and armored vehicles where personnel encounter relatively violent motion in enclosed spaces with poor visual cueing, and even simulators or manned/unmanned platforms using remote viewing sensors.

The currently used regimen of meclizine is not always effective and there are concerns about sedation with this medication. Transderm scopolamine is another option but is more expensive and also may be associated with possible adverse effects. There are physical interventions available to address motion sickness too, including accupressure, electro-nerve stimulation, and artificial horizon optics, but these have their own side effects and operational limitations.

The intent of the SBIR is to consider that technology has moved on and supports a re-look at this problem. This SBIR seeks to develop and apply a physical or pharmaceutical intervention that provides relief or prevention from motion sickness without physical or cognitive side effects, and operational limitations.

PHASE I: The primary vectors leading to side effects and after effects induced by small maritime craft and aircraft have been well studied by DoD, NASA, and civilian transportation organizations. Considering the design and operating profile of SOF maritime and air platforms, and based on a literature search of motion sickness studies, develop a device or family of devices and/or identify FDA-approved medical interventions that will prevent/reduce these effects. Build a brass-board prototype and/or obtain medical interventions and demonstrate their efficacy at a laboratory level. Finally, develop design requirements and an experimental protocol supporting further exploration of the device/pharmaceuticals' capabilities.

PHASE II: Build several candidate devices as designed in Phase I, and/or obtain necessary quantities of medicinal interventions. Execute the experimental protocol, which shall include at least one series of tests conducted at sea either on a Naval Special Warfare Craft or on a similar craft. Quantitatively evaluate the effectiveness of each device in cognitive and physical readiness terms.

PHASE III DUAL USE OPPORTUNITIES: Effective and non-debilitating motion sickness interventions are critical to military, commercial, and leisure activities such as diving, driving, aircraft/boat piloting, space travel and parachute operations.

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KEYWORDS: Motion Simulation; Motion Sickness, Motion Side Effects, Motion After Effects, Vertigo

OSD Deputy Under Secretary of Defense (S&T)/
Defense Health Program (DHP)
Information Technology Topics for Military Health System (MHS)

The Jointly Sponsored Deputy Under Secretary of Defense (S&T) and Defense Health Program Office have established this Small Business Innovative Research (SBIR) program focus area to do applied research on Information Technology (IT) issues directly supporting the Military Health System (MHS). The MHS has approximately 80 major Military Treatment Facilities, 500 clinics, 160,000 healthcare personnel, and 8.3 million eligible beneficiaries. This health system results in approximately 900,000 outpatient visits and 10,000 hospital admissions per week.

The objective of these topics is to support the Military Health System optimization plan that includes the areas of:

1) Access to care, 2) Provision of care, 3) Manage the business and 4) Population health management.

On the following pages are the SBIR topics in this technology area, which are managed by Telemedicine and Advanced Technology Research Center, which is a part of Army Medical Research and Material Command at Ft. Detrick, Maryland:

1. OSD01-DHP10 Technology Enhanced Human Interface to the Computerized Patient Record
2. OSD01-DHP11 Cognitive Patient-Clinician Encounter Model
3. OSD01-DHP12 Health Information Data Mining

TOPIC NUMBER: OSD01-DHP10

TITLE: Technology Enhanced Human Interface to the Computerized Patient Record

DOD CRITICAL TECHNOLOGY: Information Technology – Military Health System

MAIL ALL PROPOSALS TO:

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Fort Detrick, Maryland 21702-5012
301-619-4059 Email: Richardson@tatrc.org

OBJECTIVES: Technology enhanced human interface to the military computerized patient record in the context of an automated data collection and medical documentation methodology with associated technologies to optimize the physician patient interaction during medical encounters.

DESCRIPTION: The goal of MHS is for military physicians to spend not more than 15 minutes with each patient during routine outpatient appointments. Current requirements for administrative and medical data collection for the MHS Military Treatment Facilities (MTFs), and collection of information for diagnosis and treatment by the provider from sources other than the patient significantly detract from the time the physician has to directly interact with the patient for examination, diagnosis, treatment, and consultation. Research needs to be performed on methodologies and technologies to enable necessary data collection without impacting patient/physician interaction. A program is underway to develop a Computerized Patient Record (CPR). MTF health care providers currently use a combination of handwritten and computerized data entry techniques to capture and document the clinical encounter. The desktop workstations currently employed to capture this information seem to hinder the productivity as the Military strives to deliver effective and efficient healthcare. A method is needed to reduce the footprint of the computer workstation and integrate several capabilities into an efficient and practical hand-held devices and potentially wireless environment. In order to improve work processes the new automation system needs to address capabilities, such as hand held devices with

A Clinic and/or provider role-specific practice management system with Cached appointed patients with Patient Encounter Modules (PEMs) for:

a) Patient demographics and immunizations
b) Patient active meds/allergies and drug-drug interactions
c) Patient problem list and alerts
d) Local registration, appointing & scheduling
e) Order entry, status and results retrieval
f) Voice transcription & speech recognition
g) Encounter Notes using natural language processing (NLP)
h) Coding for billing based on NLP auto processing
i) XML compliant web enabled open architecture approach
j) Biometric identification and login

PHASE I: This phase focuses on developing methodologies and technological concepts to enable the collection of necessary data without impacting patient/physician personal-interaction. The proposed research should examine how to provide integrated computer-based health care information capabilities into efficient and practical hand-held devices that utilize potentially wireless and secure information technologies, and can be used throughout the military continuum of care, from forward deployed to fixed medical facility environments. The researcher will do a literature search; define health information integration, patient safety, and security requirements; define and analyze technology approaches; and prepare a preliminary technical and operational design for application of candidate technologies to patient/physician interaction within the entire military continuum of care.

PHASE II: The researcher will demonstrate construct a prototype system test bed to analyze and test the recommended/selected technological concepts and methodologies and then continue to examine additional scenarios and Patient Encounter Modules (PEMs). The prototype should demonstrate how technology enhanced human interface to the military computerized patient record in the context of an automated data collection and medical documentation methodology with associated technologies can optimize the physician patient interaction during medical encounters.

PHASE III DUAL USE COMMERCIALIZATION: This SBIR has strong commercialization potential Phase III should provide an information technology solution to Department of Defense, Department of Veterans Affairs and commercial healthcare activities. This technology may potentially benefit NATO countries as they move to modernize their healthcare delivery systems.

Candidate technologies designed and demonstrated under this SBIR project should be readily applicable to provision of health care within civilian settings with extensive continuum of care business practices that resemble those of the military; these would include those enterprises such as HMOs that encompass a full range of services from outpatient primary care in remote clinics to intensive care within large teaching medical centers.

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KEYWORDS: Information Technology, military, Healthcare, CPR, Computerized Patient Record, PDA, hand held devices**.**

TOPIC NUMBER: OSD01-DHP11 TITLE: Cognitive Patient-Clinician Encounter Model

DOD CRITICAL TECHNOLOGY: Information Technology – Military Health System

MAIL ALL PROPOSALS TO:
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OBJECTIVES: Investigate knowledge management technologies to develop a physician and patient encounter model to provide problem-oriented user-definable information in the appropriate form and at the appropriate time.

DESCRIPTION: SBIR proposals should suggest novel ways to display complex integrated clinical data. Not all clinicians have working for them, a supporting staff member whose job focus is to gather the appropriate patient data in a packet prior to the appointment. Programs exist in the area of clinical trials that look for trends, graph labs with graphical representation of high and low limits and arrows coded with intervention; but they have not been applied to support normal, non research oriented, clinical practice.

In the case of a physician patient encounter, the physician user of an integrated medical information system should be able to identify the specific information needed for the encounter, how it is to be displayed, at what time during the encounter in order to conform to his/her own view of the problem. An example of a first step solution to this problem is a web browser user interface which can be dynamically configured by the user to display the information needed in the format desired; the next step would be for the computer to learn from experience with each user, and subsequently predict the desired views of each type of problem for each user. In order to be responsive, the "intelligent" user interface must also be connected to an efficient back-end processor that is able to retrieve, analyze, and format appropriate information from diverse sources, such as records of medical history and physical examinations, ancillary test results, imagery and other patient information to support a specific medical encounter. Once retrieved and processed, the information should be displayed in such a manner as to help the physician to quickly formulate or improve the physician's big-picture view (i.e., "Gestalt") of the patient within the context of specific symptoms and problems. The user interface should be web-based to support enterprise wide access to the information.

A patient is a set of ongoing problems that are interrelated. When you go to take your car in for your 50,000 miles check up would you go back if they only repaired but did no maintenance? A patient should be seen as a whole, not a part isolated and out of context. Until we can present a Gestalt vision of a patient that a physician can look at a glance, technologists will be doing nothing innovative; but just presenting incomplete information within a new platform. Each medical specialty has specific packets of information they need to perform their job, but the generalist, the internist or family practice practitioner must see it all in a glance to truly manage the patient and take care of "repairs". With each encounter the clinician should be presented with a snapshot of data related to the patient's specific problems so the clinician can quickly address the current problem, within the context of the whole patient and take care of maintenance simultaneously. The problem list with all integrated data is a start.

As an example, within a cardiovascular patient view, should be a chronology of interventions and findings (tabular or graphical display) of echocardiograms (date and abnormal findings), EKGs (e.g., date and summary, linked to views), stress tests, multi-gated nuclear medicine imaging for ejection fraction and wall motion abnormalities (MUGA), blood pressures graphed with intervention/meds, coronary artery bypass surgery(s) (CABG date and vessels), abnormal physical examinations (e.g., pedal edema), and related risks (e.g. cholesterol, values graphed with intervention; diabetes mellitus (DM) with medication list, A1C (hemoglobin marker of glucose levels), albuminuria (albumin in urine), foot exam, eye exam dates, and significant findings; exercise program and compliance information, diet consultations and program compliance information, alcohol and cigarette usage, medication compliance score (obtained from pharmacy record already in the ancillary clinical health care system database) and laboratory results. When this information is presented in a single screen, with an optimal single view, the clinician will immediately have a broad view of a physiological system (e.g., cardiovascular) and therefore be able to address subproblems in the context of the whole instead of just the part. We need a better way to present clinical data to ensure it is complete.

A template can work for a quick problem, but one should also be able to quickly annotate the problem list with the necessary information as needed, therefore viewing the patient as a whole and his specific complaint as a subset of that whole patient. In that way, a clinician can, within a 15-20 minute encounter, care for a specific problem (e.g., bronchitis) and also evaluate the whole patient and with a directed history address what the clinicians training and experience is telling them is the most important problem and not just what the patient or medic or secretary has recorded as the chief complaint.

PHASE I: This phase focuses on developing methodologies and technological concepts to enable the presentation of necessary data without negatively impacting patient/physician interactions. The researcher will do a literature search, define health information integration requirements, define and analyze technology approaches; and prepare a preliminary technical and operational design for application of candidate technologies to patient/physician interaction within the entire military continuum of care from the forward deployed to fixed medical center environments.

PHASE II: The researcher will construct a prototype system test bed and enlarge the range of existing scenarios. The prototype should demonstrate how knowledge management technologies to develop a physician and patient encounter model could provide problem-oriented user-definable information in the appropriate form and at the appropriate time to increase the quality of the physician patient interaction during medical encounters.

PHASE III DUAL USE COMMERCIALIZATION: This SBIR has strong commercialization potential Phase III should provide an information technology solution to Department of Defense, Department of Veterans Affairs and commercial healthcare activities. This technology may potentially benefit NATO countries as they move to modernize their healthcare delivery systems.

Candidate technologies designed and demonstrated under this SBIR project should be readily applicable to provision of health care within civilian settings with extensive continuum of care business practices that resemble those of the military; these would include those enterprises such as HMOs that encompass a full range of services from outpatient primary care in remote clinics to intensive care within large teaching medical centers.

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KEYWORDS: Information Technology, military, Healthcare, CHCS, CHCS II, Pharmacy, Laboratory, Radiology, scheduling, patient encounter

TOPIC NUMBER: OSD01-DHP12 **TITLE: Health Information Data Mining**

DOD CRITICAL TECHNOLOGY: Information Technology – Military Health System

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OBJECTIVES: To investigate technologies and methodologies and to develop approaches and computational tools for performing data mining that is capable of supporting epidemiological research and comparative analysis on vast arrays of clinical and non-clinical data.

DESCRIPTION: One of the primary uses would be to allow healthcare researchers to perform data analysis to determine the effects of certain illnesses on individuals total careers and develop accession standards to allow for the best possible screening of entry recruits. Other aspects of Data Mining of the clinical data stored in the Military Health System (MHS) Data Repository (MDR) would allow for comparative results of treatment outcomes and procedures at different health care facilities within the overall MHS systems. Algorithms could be developed to provide early detection and notification of possible biological or chemical exposures of personnel by relating observed symptoms against the time history of duty locations. The government will provide access to appropriate data.

The possibilities of improving medical care via the use of information collected from data that are and will be in the MHS Data Repository databases are tremendous. Data Mining on an individual's health information will allow the provider a detailed medical history, master problem analysis, drug reactions, and health care trends in a matter of seconds instead of minutes or hours if assessed from the current system of paper and electronic records. It will also allow for improved business practices in the MHS.

For non-clinical information, the tools should gather, integrate, aggregate, and display staffing, financial, facility characteristics and other business data to characterize the performance of all aspects of MHS Operations. This includes integration of both direct care and purchased care. Significant increases in the scope of non-clinical data in the MDR include all staffing, manpower and personnel; facility characteristics; and data to support oversight and management of contracted Managed Care Support Contracts (MCSCs), provided by non MHS organizations. This is the business side of the fully evolved and fully populated MHS data repository.

The Data Mining tools might utilize natural language or other artificial intelligence technique and user-friendly interfaces to eliminate any burden on the user/provider to interact with the software. The tool must be robust enough to support simple data search and retrievals as well as queries involving complex data analyses and inductive capabilities.

PHASE I: This phase focuses on doing literature search, requirements refinement, scope definition, alternatives analysis and preliminary business case development. The researcher will do a literature search, define health information integration requirements, define and analyze technology approaches and prepare a preliminary technical and operational design for application of candidate data mining technologies with potential for supporting epidemiological research and comparative analysis on vast arrays of clinical and non-clinical data within the entire military continuum of care from the primary care outpatient clinics to the fixed medical center environments. Phase I should also demonstrate, to the maximum extent possible, proof-of-feasibility of the approach to be prototyped in the subsequent Phase II.

PHASE II: The researcher would construct a prototype system test bed of data mining tools and similar candidate technologies with potential for supporting epidemiological research and comparative analysis on vast arrays of clinical and non-clinical data within the entire military continuum of care that might utilize natural language or other artificial intelligence technique and user-friendly interfaces to eliminate any burden on the user/provider to interact with the software. The tool must be robust enough to support simple data search and retrievals as well as queries involving complex data analyses and inductive capabilities.

PHASE III DUAL USE COMMERCIALIZATION: This SBIR has strong commercialization potential Phase III should provide an information technology solution to Department of Defense, Department of Veterans Affairs and commercial healthcare activities. This technology may potentially benefit NATO countries as they move to modernize their healthcare delivery systems.

Candidate technologies designed and demonstrated under this SBIR project should be readily applicable to provision of health care within civilian settings with extensive continuum of care business practices that resemble those of the military; these would include those enterprises such as HMOs that encompass a full range of services from outpatient primary care in remote clinics to intensive care within large teaching medical centers.

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